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REPORTS

OF

Mr. ISAAC SHONE,

C.E. AND M.E., F.G.S.,

ON THE

DRAINAGE OF SOUTHPORT,

WITH A PROPOSAL FOR DEALING WITH THE

SEWAGE OF THE "ALBERT ROAD" DISTRICT,

ILLUSTRATIONS OF THE

PNEUMATIC SEWAGE EJECTOR,

AND

Extracts from Evidence given by Sir J. W. Bazalgette, C.E., and Mr. Joseph Brierley, C.E., before Committee of the House of Commons on Southport Improvement Bill (1875), *20th April*, 1875.

PREPARED AT THE REQUEST OF THE COMMITTEE FOR REMOVING THE NUISANCE OF SEWER GAS FROM THE HOUSES AND STREETS OF SOUTHPORT.

LIVERPOOL:
THOMAS BRAKELL, PRINTER, 58, DALE STREET.
1883.

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PENTREFELIN HOUSE,

Wrexham, April 12th, 1883.

TO THE COMMITTEE FOR REMOVING THE NUISANCE OF SEWER GAS FROM THE HOUSES AND STREETS OF SOUTHPORT.

GENTLEMEN,

In compliance with your request that I should state to you (*a*) my opinion of the system of drainage which is in existence at Southport, and which was designed by Mr. Mansergh, C.E.; (*b*) my opinion of the proposed extensions of the same system; (*c*) my opinion as to whether or not the "Shone System" can be applied wholly or in part to Southport; and (*d*) supposing the "Shone System" to be applicable, what would be the probable cost and the effect sanitarily of applying it; I beg to report as follows:—

(*a*) I consider the present system defective in the extreme.

1. That you may understand what good drainage means, I will quote what the Chief Engineering Inspector to the Local Government Board, Mr. Robert Rawlinson, C.B., C.E., states, in his valuable "Suggestions as to the preparation of District Maps and of Plans for "Main Sewerage, Drainage, and Water Supply," on the subject. **Robert Rawlinson, Esq., C.B., C.E.**

"A complete system of sewers and drains will not contaminate "houses by sewage gases, but will regularly and evenly transmit all "waste water, and all excreta, hour by hour, and day by day to the "outlet."

2. In order to make Mr. Rawlinson's statement more specific and clearer to you, I will quote what Mr. Baldwin Latham, C.E., states in his work on Sanitary Engineering, on pp. 80 and 81. **Mr. Baldwin Latham, C.E.**

"The author in the course of his experience has found that, in order "to prevent deposit in small sewers or drains, such as those of 6 inches "and 9 inches diameter, a velocity of not less than 3 feet per second "should be produced; sewers from 12 to 14 inches diameter should "have a velocity of not less than 2½ feet per second; and in sewers of "larger dimensions, in no case should the velocity be less than 2 feet "per second*. Recently the author has been called upon to reconstruct "the sewers of several towns, in which they have ceased to work by "reason of the inattention paid to matters relating to fall; and practical "experience now clearly demonstrates that no sewers ought to be con-"structed with less fall than to give the velocities above mentioned. "In order to maintain these velocities in sewers, it is absolutely requisite "that a certain rate of inclination should be secured; thus, small sewers "will require a greater rate of fall than large sewers; and large sewers, "on the other hand, must have provided a much larger volume of "fluid, so that the proper velocity through them may be maintained."

3. I may add that if you asked the highest living sanitary engineering authorities the question, whether Messrs. Rawlinson and Latham have fairly represented the conditions essential to the efficient drainage of sewage from our houses and towns, their reply would undoubtedly be in the affirmative; and, if so, let us see whether my remarks (*a*) descriptive of the drainage system adopted in Southport, and which is about to be extended,—viz., that it is "defective in the extreme,"—are correct or not.

References to Table (5) on p. 3.

4. The following table (5) will shew the gradients at which sewer pipes should be laid, and the population and volumes of sewage (reckoning it at 25 gallons per head per day), which are required to make them self-cleansing and free from deposit. It will shew the gradients at which the sewers should be laid, when they are used for the passage of both sewage and street rainfall waters, and it will also shew the sizes of the main sewers and the gradients adopted at Southport. In short, this table, viewed alongside the accompanying sections Nos. 1, 2, and 3, will demonstrate the fact, that the existing main sewers of Southport are "defective in the extreme," and that it is a mockery of the science of hydraulics to say that they are otherwise.

* For the same reasons the Southport Corporation may sooner or later call in Mr. Latham, or some other engineer, to reconstruct the proposed new sewers of Southport.

(5). TABLE REFERRED TO ON PAGE 2.

NOTE.—Column 2 in this Table is very instructive. For example, it shows that a 5" pipe will discharge 55·9 times as much as a 1" pipe, a 12" pipe laid at the same gradient will discharge 498·8 times as much as the 1" pipe, and ergo the 12" pipe will discharge (498·8 ÷ 55·9) = 8·925 times as much as the 5" pipe, and vice versâ.

1	2	3	4	5	6	7	8	9	10	11	12
Diameter, in inches, of circular sewers.	d. 2·5	Gradients at which the circular sewers should be laid for sewage.	Gradients at which the circular sewers should be laid when sewage and street-water are admitted into them.	Gradients adopted in Southport for the small tributary circular sewers. (These vary from 1 in 43 to 1 in 800.)	Number of cubic feet per minute required to half fill the sewage pipes (3), to render them self-cleansing.	The population required to supply the sewage pipes, reckoning 25 gallons of sewage per head per day, and the half to pass away in 400 minutes, (the pipes flowing half-full.)	Dimensions of circular and egg-shaped main sewers of Southport, designed by Mr. Mansergh, C.E.	Gradients at which the circular and egg-shaped main sewers of Southport are laid.	The velocity the sewage would attain if the Southport circular and egg-shaped main sewers were always open at the outlet, and running ½ and ⅔ full respectively.	Number of cubic feet per minute required to half fill the circular and two-thirds fill the egg-shaped main sewers of Southport.	The population necessary to supply the volume of sewage required for the Southport circular and egg-shaped main sewers when running ½ and ⅔ full respectively.
									PER SECOND.		
5″	55·9	1 in 100	1 in 50		12·40	2,480	12″	1 in 4000	·74ft.	17·5′	3,500
7″	129·6	1 in 150	1 in 70	average	23·56	4,712	·15″	1 in 4000	·83ft.	30·7′	6,140
							18″	1 in 1000	1·75ft.	92·47′	18,500
9″	243·0	1 in 200	1 in 90		38·17	7,644	21″	1 in 1500	1·61ft.	116·62′	23,324
10″	316·2	1 in 200	1 in 150	about	49·60	9,920	3′0″ × 2′0″	ditto	1·93ft.	175·42′	35,084
12″	498·8	1 in 250	1 in 200		69·70	13,940	ditto	ditto	ditto	ditto	ditto
15″	871·4	1 in 400	1 in 250		112·30	22,460	ditto	ditto	ditto	ditto	ditto
18″	1375·0	1 in 500	1 in 300	1 in 200	136·78	27,356	5′0″ × 3′4″	1 in 3000	1·76ft.	443·52′	88,700
24″	2822·0	1 in 800	1 in 400		222·06	44,412	6′0″ × 4′0″	1 in 5000	1·5ft.	543·0′	108,600

6. If you will carefully peruse the above table along with the sections Nos. 1, 2, and 3 sent herewith, you will readily understand how it comes to pass that the existing sewers smell, and give you and other residents in Southport anxiety.

7. The sections shew the sizes of the sewers, and gradients at which they should be laid, in red ink,* in contradistinction from the sizes and gradients of the sewers as they have been laid by Mr. Mansergh, which are shewn in black ink.

Section No. 1.

8. You will see, for instance, that section No. 1 shews that if the sewers had been laid according to Messrs. Rawlinson and Latham's directions, the sewer at the outlet, if it followed the line of the existing sewer, would be 59 feet below the invert of the present iron outlet sewer at Crossens!

Southport not built on a declivity.

9. If Southport had been built on a hill, having a declivity or a profile similar to the red lines* marked upon the sections, Mr. Mansergh would have been able to engineer the sewage away as it should be engineered away, *i.e.*, sanitarily; but Nature having left the surface of the ground at Southport practically flat and level, Mr. Mansergh, failing to devise a scheme whereby Nature's disadvantageous conditions could be overcome, succumbed to Nature; and hence the smells of which you complain.

Mr. John Phillips, C.E.

10. A very eminent practical sanitary engineer (Mr. John Phillips, C.E.),—who was formerly chief surveyor of a large portion of the metropolitan sewers, and whose opinions, &c., are quoted in Mr. Baldwin Latham's work, already referred to,—alluding to the necessity there is for reducing the air-space in sewer pipes, stated, "From this it "is obvious that the less the sewage is exposed to air, and the less air "space there is above it,—in fact, the nearer the sewer capacity is "brought to the sewage capacity—the less gases emanate from the "sewage. This desideratum is to be attained by altogether excluding "the rainfall from the sewage channels, and then reducing their capacity "to the capacity or minimum flow of the sewage. But by making the "sewers, as we do, large enough, and often many times larger than are "requisite, to accommodate the rainfall, the sewage, which occupies "only a small space at the bottom of the sewers, is necessarily spread "out and exposed to a large body of air, which promotes its decompo-

* On the original Drawings they are in *red*, but on the lithographed copies they are readily distinguishable in black.

"sition, and the emanation of gases from it, whether it be flowing or "stagnant; and then, owing to the extreme volatility of these gases, "they flow up the drains, and bear on all the traps, through which they "escape, as before described. Thus, the ramification of sewers and "drains, as now put down, is neither more nor less than a vast gas-"producing and gas-distributing apparatus, and in the air thus con-"tinually polluted we are doomed to live! The remedy for this evil "consists, as already stated, in excluding the rainfall from the sewage, "and then reducing the sizes of the pipes to the maximum quantity of "sewage, the evaporating surface of which, and the amount of gases "emanating from it, would then be reduced to a minimum."

Cubic capacity of Southport sewers equal to a trough 152 miles long.

11. To give you some idea of the disproportion that exists between the sewer capacity and the sewage capacity of the Southport sewerage system I have made a rough computation of the number of cubic feet contained in the Southport main, tributary, and house sewers, and I find it amounts to 803,396 cubic feet!

12. If a trough 1 foot square was made about 152 miles in length it would represent the space provided for the sewage of Southport; and as the whole day's supply would barely at any time exceed on the average 180 cubic feet per minute, this latter quantity, if uniformly spread over the bottom of the trough 152 miles in length, would only be equal to the $\frac{1}{3\frac{1}{4}}$ part of an inch in depth!

Conditions essential to the abrogation of sewage-gases ignored in Southport

13. So far from adjusting the sewer capacity to the sewage capacity, in order to reduce the quantity of sewage gas to a minimum, the very converse of this has been done in Southport, as the above calculation will demonstrate.

14. That the evils of which you complain *do* exist is abundantly apparent, too, from the reply which the Town Council of Southport has given to the report recently published by your Committee. I beg to reproduce here those portions of the reply of the Town Council to which I now particularly refer; and if these statements, put forward by the Town Council, do not prove the existence of sewage gas, and the necessity there is for flushing the sewers in which the sewer gas is generated, I do not know what they are intended to prove; and, if they prove that, they also prove that in spite of the apparently extra-ordinary and costly measures taken by the Corporation to suppress sewage gas nuisances to your and their own satisfaction, they continue to exist! The Town Council states:—"The ventilation of drains and "sewers has been constantly augmented since July, 1880, not to

Sewage-gas nuisance not suppressed notwith-standing precaution-ary measures taken by the Corporation.

Part of the reply of the Town Council to the complaints of the Committee.

"mention nearly 200 ventilating shafts put up in the year ending "March 25th, 1880. 517 were added in the year ending March 25th, "1881, and 410 in the year ending March 25th, 1882, and about 100 "more have been since added. The shafts now put up can only be "erected by and with the consent of both owners and occupiers, and "this is by no means constantly given, or given immediately. The "total number of ventilating shafts of all dimensions is not much "under 3000, and the total sectional area of these shafts is over 156 "square feet. It is hardly fair to speak of these shafts as a 'mere "fraction' of the number required when the total number of houses "in the borough connected with sewers is under 5000, and the ventila- "tors are 3000, ventilating 4000 out of the 5000 premises connected "with sewers. Such a proportion is not correctly described as 'a "mere fraction.' To these air shafts on private premises may be "added one 9-inch ventilating shaft from the Albert Road sewer to "the Glaciarum chimney, specially provided for the relief of that "sewer, one 9-inch shaft at the Baths chimney, and two 6-inch shafts "at the Gas Works chimney in Eastbank Street; and finally, 120 "additional street grids have been put in since July, 1880. And yet, "in this respect also, the Committee charges the Corporation with "making no effort to provide a remedy. . . . . Since the recom- "mendation for increased flushing in 1880 the average daily amount of "Waterworks Company's water used for flushing has been 38,181 "gallons, *i.e.*, more than double. In addition to this, 12,462,415 "gallons of water from the lake in Hesketh Park have been run "through Park Road sewer at intervals during the last year, and nearly "14,000,000 of gallons of water from other sources into other sewers "(not to mention twenty-four high tides during the year, which have "been utilised to flush the main sewers), making an amount of supple- "mentary clean flushing water equal to a daily average of about 72,000 "gallons, irrespectively of the tidal water. But the Committee says "that no effort has been made to provide a remedy!"

15. With regard to the number of ventilators being adequate or inadequate, I would remind you of the opinion which I understand your Medical Officer of Health holds, in common with a great number of other gentlemen, viz., that Southport would be better if all its sewers were so many *uncovered* conduits, permitting the gases to escape everywhere along the line! If this theory be good, then, to all intents and purposes, the statement made by you, and contradicted by the Council, to the effect that the number of the ventilating shafts already

Ventilators inadequate.

fixed is "a mere fraction of the number required," would appear to be under rather than over-stated; for, having regard to the air surface to which the sewage of Southport is exposed, the 156 square feet, which is the area of the whole of the ventilating shafts on the Southport sewers, is indeed infinitesimally small, in comparison with what it should be.

16. Again, the statements advanced by the Council with regard to flushing are calculated, in my humble opinion, to mislead the Council itself. Let us take what is stated about the Albert Road sewer being flushed every day by the waste waters from the Baths. The 100,000 gallons in winter, and from 300,000 to 400,000 gallons of Bath waters per day in summer, give an imperfect idea of the flushing power available at the Baths. Mr. Crabtree, in his paper read before the members of the Institute of Municipal Engineers and Surveyors, states, "The Nevill Street sewer is flushed from the Baths, which have one "bath containing 65,840 gallons, two of 50,000 each, one of 55,228, "one of 45,668, one of 40,608, two of 28,000 each, or a total of "332,000 gallons, which in the summer season are emptied every night, "and in winter twice per week"; which does not quite correspond with the reply of the Town Council quoted above. However, adopting the larger quantity, then 400,000 gallons is equal to 64,000 cubic feet, and if this were running regularly throughout the day, it would be equal to 44 cubic feet per minute only; but if the above quantity was discharged in say three hours—and I doubt if all the baths are emptied simultaneously—then the quantities would range from 89 to 266 and 355 cubic feet per minute respectively.

Flushing.

Flushing by salt water from the Baths, which is heated, is calculated to aggravate the smells.

17. To judge of the efficiency of the flushing power at the disposal of the Council, regard must be had to the carrying power of the sewers flushed; but the bath water does, no doubt, help in keeping the main sewer below Nevill Street clear of deposit. It in no way, however, helps the Lord Street main sewer, at its *head*, where the flushing power should be situate; nor does it favourably affect the other two main sewers. On the contrary, if the inverts of the other two main sewers join the invert of the principal tank sewer, at the same level, *i.e.*, without any drop, the water from the Baths would impede the free outflow of the sewage due from the main sewers, at the points where the latter unite with the main trunk sewer; and it certainly would have this effect at the point where the Baths' water flows into the main sewer under Lord Street.

Defective state of Lord Street sewer at its head, demonstrated by Table (5).

18. The columns 8, 9, 10, 11 and 12, and the figures in the first four lines from the top, in the table on page 3, will shew you the conditions that apply to the main sewer under Lord Street, between its head, at the Birkdale boundary, and the point opposite Nevill Street, where the Bath waters flow into it. Column 8 gives the sizes of the pipes laid down; column 9 shews the gradients at which they are laid; column 10 shews the velocities in feet per second which the fluid would attain, when it filled or half-filled the sewer; column 11 shews the number of cubic feet which each sewer requires to half-fill it, if it is a circular sewer, and two-thirds fill it, if it is an egg-shaped sewer; and column 12 shews the population required to either half-fill the circular sewers, or two-thirds fill the egg-shaped sewers.

Table (5) shews that even with good gradients, pipes of small and large bore must have sewage passed into them or they will become foul, good gradient notwithstanding.

19. It will be seen that a pipe 12 inches in diameter, to discharge sewage at a velocity of 3 feet per second, *must* be laid at a gradient of 1 in 275 (*vide* column 3 in the table), and the sewage of 13,940 people *must* be discharged into it, before the fluid can possibly attain the velocity stated; whereas the 12-inch pipe sewer, laid at the very head of the Lord Street main sewer, is fixed at a gradient of 1 in 4000! and would require to be supplied with the sewage of 3,500 people, in order to half-fill it only, and the velocity of the fluid, even then, would barely be 9 inches, instead of 36 inches per second! As a matter of fact, however, the population contributing to the 12-inch sewer under Lord Street would be "a mere fraction" of the population given in the column 12 of the table (5) as *the population which the hydraulic law imperatively demands*, before a velocity of 3 feet per second can be secured! It is for the want of a practical approximation to that hydraulic harmony which must subsist, so to speak, between the sizes of the sewer-pipes and gradients, as well as between the sizes of the sewers and the volumes of sewage available, that the system of drainage now in operation in Southport fails to work satisfactorily.

Cause of the failure of the present system of drainage in Southport.

Hydraulics of drainage difficult to comprehend by the uninitiated.

20. It is difficult to explain to people who do not understand practical hydraulics what is involved in the points urged by the authors of the statements in paragraphs Nos. 1, 2, and 10. Let me try to shew what is meant. The population of Southport is, say, in round numbers, 30,000; and the water-supply, which would also be approximately the sewage supply, is equal on the average to 30 gallons per head per day; this would give (30,000 × 30) 900,000 gallons as the whole day's supply of sewage. If we assume again that the half will pass to the outfall in 400 minutes, then the greatest average quantity

Southport sewage 900,000 gallons per day.

that would pass to the sea, through the outfall-pipe, would be (450,000 ÷ 400) = 1125 gallons per minute. If we put this quantity in a pipe running full bore, in order to permit the sewage to flow at a velocity of 2½ft. per second, the pipe should be 14in. in diameter, and it should be laid at a gradient of 1 in 430; but if the quantity of 1125 gallons per minute were put into a pipe flowing *half-full*, the size of the pipe should be 21in. in diameter, and laid at a gradient of 1 in 650. The velocities in pipes running full and half-full being the same, it is clear that if a 21-inch outfall pipe were put down, such a sewer would suffice for double the population; *i.e.*, for 60,000.

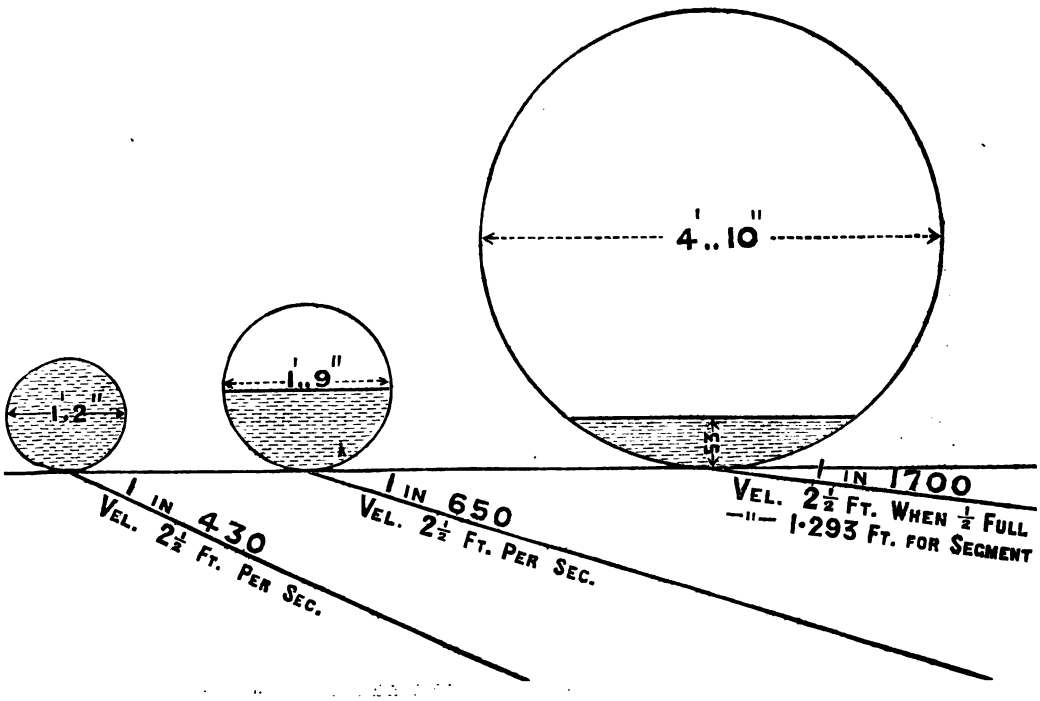
Sizes of sewers required for 900,000 gallons of sewage per day.

21. But what are the facts of the case. Mr. Mansergh put down an egg-shaped outfall sewer 6 × 4ft., laid at a gradient of 1 in 5000!

Mr. Mansergh's outfall sewer.

22. An egg-shaped sewer of these dimensions has a sectional area very nearly equal to a circular pipe of 4ft. 10in. in diameter. The relative areas of the pipes may be judged of thus:—

Comparisons to shew unsuitability of big sewers of Southport for sewage supply.



Reference to diagrams of sewers.

23. The lined parts of each of the above circles show the relative areas occupied by the sewage. The blank portions of the two larger circles show the relative air spaces. The velocities are given in feet per second for each size when flowing full or half full, and also for the segment shown in the largest circle. The latter would give a quantity of sewage equal to the half of the 21-inch or the whole of the 14-inch pipe, laid at the respective gradients given.

Capacities of pipes not as the squares of their diameters.

24. But although the sectional areas of pipes vary as the squares of their diameters their capacities to discharge sewage are not to be measured in that ratio when the gradients are the same.—*Vide* table (5), column 2.

Important comparisons to shew the relative capacities of pipes to discharge sewage.

25. The gradient at which the larger pipe of 4ft. 10in. in diameter should be laid to secure a velocity of 2½ feet per second would be say 1 in 1700; but whilst the area of the smaller pipe of 14 inches in diameter is (18·35 ÷ 1·07) about the $\frac{1}{17}$ that of the larger one, yet, because it is a hydraulic fact—if I may so express myself—that the capacities of pipes to discharge liquid under the same gradients or heads of water, varies as the square root of the 5th power of their diameters (see column 2 in table on page 3), and not as the squares of their diameters. The 14-inch pipe, laid at the gradient of 1 in 1700, will discharge only the $\frac{1}{35}$ part of the 4ft. 10in. sewer! On the other hand, if you put the 4ft. 10in. sewer at the gradient suitable to the 14-inch pipe, viz., at 1 in 430, it would discharge thirty-five times as much as the 14-inch pipe sewer!

Present sewers of Southport radically wrong.

26. From the table and what I have stated it will be evident to you that the sewer pipes already constructed, and the sewer pipes proposed to be constructed and reconstructed in Southport, cannot "regularly "and evenly transmit all waste water and all excreta hour by hour "and day by day to the outlet," as Mr. Rawlinson states in his "suggestions" every "complete system of sewers and drains" should do; neither are the main sewers in existence, nor those which are proposed to be constructed in Southport, in accordance with the rules stated so clearly and correctly by Mr. Baldwin Latham, C.E., in paragraph 10 herein; and "the amount of deleterious gases escaping from the flowing," or stagnant, "sewage being in proportion to the air surface in contact with it, or air space over it," it follows that "the nearer the "sewer capacity is brought to the sewage capacity the less gases emanate "from the sewage;" and as these conditions are unattainable by the employment of such sewers as have been constructed, and by the

Sewers proposed to be constructed same as those condemned in this report.

employment of such sewers as are proposed to be constructed and re-constructed at Southport, it also follows that unless some radical change for the better is made, the ratepayers of Southport will have to take up with the present state of things, which, I must say, is the very antithesis of that which ought to obtain in a health resort.

Covered cesspool source of danger, though ventilated.

27. Mr. Rawlinson, C.B., C.E., states also in his "Suggestions," "A "covered cesspool must be a source of danger, even though ventilated;" and what, I ask, are many of the miles and miles of the sewers of Southport but elongated cesspools? and consequently a vast "sewage-gas producing and distributing apparatus!"

Lengths of Mr. Mansergh's three main sewers.

28. The accompanying sections will help you to judge of the correctness or otherwise of the statements just made.

29. No. 1 follows the main sewers from Birkdale boundary to the outfall, which is 4 miles 1 furlong in length.

30. No. 2 from Duke Street to the outfall, which is 4 miles 1¾ furlongs in length.

31. No. 3 section follows the main sewer from the Scarisbrick New Road to the outfall, which is 4 miles in length.

32. You will see that each section shews that the outlet *must* be tide-locked at times, which is a great drawback, as of course, during those periods, the sewage, whilst ponding, causes the vitiated sewer air to pass out of the sewers in volumes corresponding to the volume of the accumulating sewage; but, apart from this drawback, there is the other drawback, viz., that the normal sewage discharges cannot possibly gravitate to the outfall, at a velocity of 3 feet per second, simply because they are allowed to pass into *big, flatly-laid sewers* instead of being passed into *small sewers* laid as they are shewn upon the sections.

The sewage of Southport cannot flow to the outfall properly.

Division of sewage between the three main sewers.

33. Dividing the whole population of Southport into six parts, I have assumed that the one-half will flow down a certain length of section No. 1; that one-third will flow down section No. 2, and the remaining one-sixth will flow down a certain length of section No. 3. But, owing to the great lengths of these sewers, the sewage, if it could flow to a non-tide-locked outlet, at a velocity of 3 feet per second, would be a long time on the way. That discharged into No. 1 would take 181 minutes; that discharged at the head of No. 2 would take 124 minutes; and that discharged at the head of No. 3 would occupy 118 minutes in its passage to the outfall.

Penstocking sewage means stopping it.

Sewage decomposes en route to outfall.

34. But when the sewage could find its way to the outfall through the present sewers, which are pen-stocked and tide-locked, I cannot pretend to say; but this I do know, that it cannot reach the outlet, as it should do, before it enters into a state of decomposition.

Dr. Vernon's testimony as to decomposition in sewers of Southport

35. Your own Medical Officer of Health furnishes the best possible evidence of this in his report to the Chairman of the Health Committee, dated 9th July, 1880. He there stated, "It must be conceded at "once, I think, that very offensive smells rise from many of the sewer "ventilators in the streets; some persons have professed, indeed, not to "be able to distinguish them, but the complaint is too general to be "attributed to a few fastidious people, who, having seen a grid, straight-"way imagined a smell. It must also be admitted that although the "public apprehensions as to the danger arising from the smells are "perhaps somewhat exaggerated, they are nevertheless undoubtedly "prejudicial to health, and from time to time, under exceptional cir-"cumstances, may be positively dangerous." In the same report Dr. Vernon points out the remedy, in the following words:—"But I desire "to point out that the only safe, thorough, and permanent remedy is to "prevent the generation of the stinks." I agree with him entirely—"Remove the cause, and you will have no effect." But the cause is immovable by the means employed, and proposed to be employed, as must be apparent from what I have stated with reference to the sizes and the gradients of the Southport pen-stocked and tide-locked sewers.

Dr. Vernon's remedy for smells from sewers quite correct.

Mr. Crabtree's testimony as to the outlet at Crossens.

36. Mr. Crabtree states in the paper before referred to, "As the "sewage can only be discharged (into the sea) when the tide has "receded below the invert of the sewer, it will be met by the incoming "tide before reaching within a mile of the pierhead, or a mile and a "quarter from the bathing ground." This looks like ponding the sewage in the sewers longer than would otherwise be necessary, in order to permit the incoming tide to carry the filthy vomit of the sewers back again, before it can reach the front of the town! I should say that the greater of the two evils is the act of retaining the sewage in the sewers longer than is permissible by the action of the tides; but the greater evil, because it is *invisible*, is made subservient, as it were, to the lesser! What is or will be the practical effect of causing the sewage to be discharged at Crossens, and afterwards to allow it to sweep up and down the channel in front of the town with the ebb and flow of the tide, it is too soon yet to predicate.

37. I observe that importance is attached to the portable flushing tanks that are in use at Southport. Discharging 1,000 gallons of water into a sewer, quickly, will no doubt have a more or less desirable *local* effect, but you might as well try to fill the Suez Canal with a tea-kettle, as try to flush and cleanse the whole system of sewers of Southport by any such apparatus !

Flushing big sewers by portable tank ineffectual in improving the general system of sewers, &c.

38. 1,000 gallons contain 180 cubic feet. If this is put in a trough one foot square, it will occupy 180 feet in length when the trough is full, 360 feet when it is half full, and 720 feet when it is quarter full, or three inches in depth. This latter depth might do if the trough were only 720 feet in length, and inclined, to permit the water to flow freely; but if the trough is several miles in length, and closed at the outlet, and practically on the level, or laid at a gradient of 1 in 5,000, how, I ask, can you efficiently flush even a trough one foot square by such means, much less an egg-shaped sewer, which has a sectional area eighteen times greater, and whose length is altogether disproportioned to the volume of sewage available from minute to minute and from hour to hour at Southport ?

39. I have taken the trouble to try to make the conditions which obtain, and which should obtain, in Southport, plain to you, so that you may judge for yourselves of the value of the remedial measures which the Corporation are now suggesting to the Local Government Board as the remedy for the existing state of things.

40. I have now to consider the (*c*) and (*d*) queries, stated at the commencement of my report.

41. My opinion is, that the Shone system is especially applicable to Southport, as, by its aid, short lengths of small sewers, properly graded to suit the volumes of sewage available, can be obtained.

Shone system designed especially for such places as Southport.

42. If a town adopted my system in its entirety, I should never have larger sewers than 5in. for houses, and these would terminate in 7-inch sewers. The former to be laid always, if practicable, at a gradient of not less than 1 in 100, and the latter 1 in 200.

Gravitating sewers required for Shone system

43. The 5-inch pipe laid at the gradient of 1 in 100, running *half-full* would deliver $(27{\cdot}3 \div 2) = 13{\cdot}15$ cubic feet per minute, and the 7-inch pipe, which would be common to all the 5-inch house-pipe sewers, would discharge, running half-full and laid at a gradient of 1 in 200, $(43{\cdot}1 \div 2) = 21{\cdot}55$ cubic feet per minute; and, therefore, assuming that the one-half of the whole of the sewage would flow through the

Capacities of gravitating pipes proposed to be used in the Shone system.

7-inch sewer in 400 minutes, and the quantity of sewage which each contributor supplied to it in twenty-four hours equalled 4 cubic feet, the population for which such a pipe would be suitable would be $\left(\frac{400 \times 21{\cdot}55 \times 2}{4}\right) = 4310$.

44. By inserting larger pipes than those named, we create conditions which would have the effect of retarding the otherwise expeditious and sanitary flow of the sewage.

Southport being flat, the gradients required are unobtainable practically by trusting to gravitation alone.

45. The surface at Southport being flat, and the gradients proposed to be adopted in our hypothetical case for the main tributary sewer of 7 inches, being 1 in 200; if we started to lay the 7-inch pipe at its head, say 4ft. deep, and 1500ft. in length, the sewer at the lowest end would be $(1600 \div 2 + 4) = 12$ft. deep. At this point, which would be perhaps under the centre of a street, where four streets converged, I should fix one of my pneumatic sewage ejectors, to receive the sewage, as it gravitated to that spot. If the sewage entering the 7-inch pipe, at its head, travelled to the pneumatic sewage ejector, at a velocity of 3ft. per second, or 180ft. per minute, it is clear that the time occupied would be less than nine minutes ! !

Pneumatic ejectors substitutes for so many pumping stations.

46. The pneumatic ejector being supplied by three other 7-inch pipes, which would bring the sewage of the houses of the three other streets, would soon get filled, and directly that event took place, compressed air would pounce on the sewage, and force it out of the ejector into an iron pipe, which would lead the sewage to the outfall; and being within an hermetically sealed pipe, subject to pressure, and consequently *full*, the sewage, having *no "air-space"* over it (10), could not decompose, and if it did, the gases could not escape, as they now do, through the ventilators and grids, which are on the main gravitating sewers.

Principle of Shone system described.

47. If Southport had been built in such a way as to admit of 4310 people draining into *one* ejector station, we should then want $(36126 \div 4310) = 8{\cdot}4$ stations only. But Southport, besides being flat, is built over sparsely; that is to say, for the area occupied, the number of houses per acre are comparatively few; and this adds to the difficulty of draining it, so as to get good gradients. Instead of 8·4, it would probably demand 20 ejector stations, and if so $(36126 \div 20) = 1806$ people would supply each of the ejector stations with sewage.

48. Compressed air, to operate each ejector station, would be supplied from some central engine, whence it would proceed, in small pipes, to the various ejector stations, just as gas proceeds from the gasworks, to supply our houses with gas; and the whole of the ejectors being automatic, the attendance at the air compressing station would be no more nor less than it would be if the sewage was being pumped at one and not at 8 or 20 pumping stations.

Compressed air delivered to ejectors through small pipes would actuate them automatically.

49. Some engineers, whose practice has been confined to constructing sewers on the gravitating plan, and who, when pumping is resorted to, fix *one* pumping engine at the outfall, have been known to shrug their shoulders and shake their heads, at the proposal to use pneumatic ejectors as substitutes for pumps—in the manner suggested herein; but when they have been asked to do something more than shake their heads and shrug their shoulders—by way of accounting for their apparent indifference—it has invariably transpired that they either could not, or would not investigate, the steam engineering, the mechanics, the pneumatics and the hydraulics, nor the hygienics and economics of the system now treated of!

Objections to Shone system not based upon a full knowledge of it.

50. Supposing you employed a Cornish pumping engine at Crossens, to pump the sewage; say into the sea or elsewhere, as it found its way to the outlet through the present sewers; the act of pumping foul sewage at Crossens, would not make the sewage discharged at the head of the present main sewers flow one inch a minute faster than it is flowing now; and a ratepayer, resident on the line of a sewer that is so conditioned that, it cannot but remain permanently foul and dangerous, would not be satisfied with the mere act of pumping sewage economically at the outfall, so long as his own drains, and the public sewers into which his own drains discharged, were the cause, for example, of a second edition of the Bangor typhoid fever epidemic—or some other fever traceable to sewage gas emanations.

Cornish or other ordinary Pumps employed to pump sewage at one Station to which the Sewage cannot flow, quickly, from all parts of the town, no remedy for defective gradients, &c.

51. The Chairman of the Local Board of Bangor stated publicly, at the time when the fever epidemic occurred there, that a gentleman had previously visited the city and, finding sewer smells almost ubiquitous there, asked if typhoid fever had not manifested itself; and on being answered in the negative, he at once expressed his surprise, and prophesied that they would not long remain without it, as they had all the conditions necessary to its generation—or something to this effect. I mention this incident, as it is a powerful argument against those who entertain the idea that, because smells have, so far, existed in

Bangor fever epidemic.

Southport, without producing any such fatal results as accrued from the Bangor epidemic—that therefore, they may safely rest assured that there is no such danger to be apprehended in Southport! If any one had ventured to remonstrate before the Local Board against the Bangor smells a month previous to the breaking out of the epidemic, doubtless the appeal would have been pooh-poohed. The most convincing proof of the danger which attaches to such work as is proposed to be carried out at Southport, viz., to re-open defective sewers, is to be found in the report upon an outbreak of typhoid fever at Newton Heath, Manchester, by Henry Tomkins, M.D., B.Sc., &c., Medical Officer to Monsall Fever Hospital, which is to be found in *The Lancet* for the 3rd February, 1883. This report is so important, in my opinion, that I think it my duty to draw your attention to it, in the hope that the Southport Town Council may be made acquainted with it.

The Lancet.

Erroneous opinion as to the gravitating plan of drainage.

52. Some engineers say, "The beauty of the gravitating plan of "drainage is, that once the work is done there is an end of it; and "costly fuel and attendance, such as apply to constant pumping, is "avoided." But assuming for a moment that you can drain the sewage of Southport just as perfectly on the gravitating plan as you can by the pneumatic plan, if the capital cost of the gravitating plan is about £100,000 more than the pneumatic plan, then, in the interests of the ratepayers, the latter should be adopted.

Comparisons of cost, between an effective and a defective Scheme, fail to convey to the mind the Sanitary aspects of each.

53. But as a matter of fact, for the reasons enumerated in this report, the gravitating plan, *per se*, can never be made to cause the sewage to flow harmlessly and regularly, from hour to hour and day to day, to the outlet; whereas the Shone semi-hydraulic and semi-pneumatic plan, adopted in its entirety, would not only make Southport "the *exemplum* for every other inhabited place," as Dr. Richardson, in his article on "Health in a Health Resort," which is inserted in *Longman's Magazine* for February, states all health resorts should be, but it would also enable you to collect and eject the sewage in a more concentrated, manageable, and valuable form for utilization upon land, than has hitherto been thought possible.

The Pneumatic System would enhance the manurial value of the sewage.

Value of sewage, as per Mr. Rawlinson, C.B., C.E.

54. The experience acquired by Mr. Rawlinson as to the value of sewage is given in his "Suggestions," and it is as follows:—"Sewage "has been valued as a manure at from ½d. to 2d. per ton. The same "sewage will, however, be worth 2d. in a dry summer which may not "be worth more than ½d. to the farmer in a wet season and through "the winter. In practice these prices frequently cannot be realised,

"not because the elements of value are not in the sewage, but because "of the extreme dilution and the difficulty of uniform and equal "manipulation; sewage, as a rule, being flooded on to the land in "volumes far too large for any crop to assimilate. If from one to "three thousand tons per acre of rich sewage could be equally and "evenly distributed over Italian rye grass (as by hose and jet) just "as it was required, an approach to the full value of the sewage would "be obtained."

55. A ton of sewage contains say 224 gallons, and, therefore, if 224 gallons is worth from ½d. to 2d., 1000 gallons would be worth from 2½d. to 9d.; and, as the sewage would cost probably less than ½d. per thousand gallons to pump it on to suitable lands, it is not unreasonable to expect that, with some means superior to that which now obtains of collecting and transporting sewage quickly to land suitable for sewage irrigation purposes, the lamentable waste of sewage which is now going on at Crossens will be discontinued sooner or later.

56. The Sewage of Southport, valuing it at the mean rate derivable from Mr. Rawlinson's estimate given above, reckoning the population to be 36,126, and reckoning the sewage, which is "the food and water supply after use," to be 20 gallons per head per day, and it would be no more than this if the town was drained on the "Shone System," the annual value would be:—

	£	s.	d.	
$\left(\frac{36{,}126 \times 20 \times 365}{1{,}000}\right) = 263719{\cdot}8$ @ $\left(\frac{2\frac{1}{2}+9}{2} =\right) 5\frac{3}{4}$d.=	6318	5	4	Approximate practical annual value of Southport sewage wasted.
Dr. Carpenter estimated that as much as 3/ per head had been actually realised with the Croydon Sewage Farm, and this would amount to 36,126 @ 3/ = ...	5418	18	0	
And the same authority, in his work on "Preventive Medicine and Public Health," estimates the ultimate practical value which liquid sewage will attain, when it is properly and systematically utilised on suitable land, at 5/ per head, and 36,126 @ 5/ = ...	9031	10	0	
	3) 20768	13	4	
Average	£6922	17	9	

57. If the above approximates to the practical value attainable under the *present* system of sewage collection and disposal I feel

confident that a higher average would obtain under the "Shone System" of drainage.

Annual value of Southport sewage equal to interest at 5 per cent. on £140,000!

58. But if we put the sewage down as being worth only £7,000 a year, it goes to shew that the interest on £140,000, at 5 per cent., is annually thrown into the sea at Southport; and if so, it also shews that the Corporation of Southport would be justified in spending a large sum of money, if only they succeed in accomplishing the two-fold object of draining the town sanitarily, and not unsanitarily, and utilizing and not wasting the sewage, as it is now wasted at Crossens.

59. I am sorry I am not in a position to submit some schemes with this report, which could be handed over to the members of the Corporation for their consideration, before they commit the ratepayers of Southport to the proposed expenditure of £20,000.

For want of data in detail, Mr. Shone not able to submit any other than the scheme applicable to Crossens only.

60. I had hoped to have been able to do so, as when one of the members of your Committee, Mr. Jno. B. Fell, C.E., of 68, Leyland Place, Southport, introduced me to the Medical Officer of Health, Dr. Vernon, and to the Town Surveyor, Mr. Crabtree, those officials, and especially Mr. Crabtree, impressed me with the idea that I should be furnished with such information as would be necessary to enable me to show you, and through you the Corporation, *how* my system could be applied at Southport. On my writing to ask for copies of certain plans, however, the Town Clerk, Mr. J. H. Ellis, informed me that Mr. Crabtree had instructions not to comply with my request. This is the more to be regretted, because, of course, if my scheme or schemes commended themselves to the judgment of the Corporation and the Local Government Board as being less costly, for instance, and superior in some important respects to those which have been already brought under their notice, it would be a pity to go on with the inferior and more costly scheme.

61. All I can do under the circumstances is to say that I should like the Corporation to give me a fair chance of shewing them what can be done at Southport on my system.

Constructing new defective sewers, will not improve old defective sewers!

62. I am as confident that the unearthing of old sewers, alleged to be defective, and substituting new ones in their place, will not mend matters, either temporarily or permanently, to any appreciable extent at least, as I am that comparatively small volumes of sewage will pond and decompose, and be a source of nuisance and danger for all time, if they are introduced into practically horizontal main sewers, such as

have been laid down at Southport; and to say that the proposed expenditure of £20,000 on new tributary sewers will produce the contrary effect, is tantamount, in my opinion, to throwing "the herring "across the track," and holding up a sort of will-o'-the-wisp before the ratepayers! As well expect a patient, suffering severely from constipation, to improve, by prescribing medicine to constipate him still more severely, as expect the general system of the Southport drainage to improve, in the absence of the conditions which are necessary to make the sewers sanitary sewage carriers.

63. It was to create these conditions, at places like Southport especially, that I designed the system which bears my name; and a number of eminent engineers and other gentlemen have told me that Southport is pre-eminently a place where my system would work well, &c.

How the Shone system gets over the gradient difficulties.

64. That you may be able the more clearly to understand how I get over *the gradient difficulty* on my system, I have had the drawing No. 4 made. It contains an ideal plan and section. I have assumed the town of Southport to be built in such a way as that all the sewage can be got conveniently to eight separate and distinct ejector stations, equidistant from each other, and all under the centre of streets. I have made the length of the ground traversed between the head of my system of sewers and the outfall very nearly the same as it is on Section No. 1. I have also fixed the tidal outlet the same in each case. Then (*a*) dividing 36,126, the present calculated population of Southport, by 8, we have (36,126 ÷ 8) 4,516 people to supply each ejector station with sewage; and (*b*) reckoning 30 gallons per head per day we should have to provide ejectors to receive, and power to eject (4,516 × 30) 135,480 gallons per day at each station; assuming, again, the half of this to flow in 400 minutes, then (*c*) we should get (135,480 ÷ 2) = 67,740 gallons flowing to each station in that time, or (67,740 ÷ 400) = 170 gallons per minute.

Reference to plan and section on drawing No. 4

65. At ejector station No. 1, we should put an outlet-pipe from the ejector, as far as ejector station No. 2, capable of passing 170 gallons per minute, at the least, at a velocity of three feet per second, and that would be, say, six inches in diameter. The outlet pipe, common to Nos. 1, 2, 3, and 4, between stations Nos. 2 and 5, would have to be large enough to pass (4 × 170) = 680 gallons per minute, and this would be 11 inches in diameter. The outlet-pipe between ejector stations Nos. 5 and 8 would have to be large enough to pass (7 × 170) =

No leakage from within or without and no ventilators or grids, on the Shone main outlet sewers!

1,190 gallons per minute, and this would be 14 inches in diameter; and the iron outlet-pipe between station No. 8 and the outfall would have to pass (8 × 170) = 1,360 gallons per minute, and this, to permit the sewage to fill the pipe full bore, and to flow at a velocity of three feet per second, would have to be 15 inches in diameter only. These iron pipes would not permit subsoil water to enter them, nor would they permit the sewage, once it was ejected into them, to escape out of them at any other point than the outfall; and it is in this way, and this alone, I conceive it practicable to effectually suppress sewage-gas nuisances, and, at the same time, to make the sewage flow to the outfall, whether the tide is in or whether it is out.

Tide would not impede flow of sewage in Shone's main outfall sewers.

66. In order to permit the sewage to flow into the sea through gravitating sewers, the outlet pipe must be kept above high-water spring-tides; not below, as it is at Southport. But by the application of my pneumatic system, although the outlet pipe is fixed in a position to correspond with the present 4-feet iron outlet sewer at Crossens, the sewage would flow into the sea precisely the same as if it had been conveyed there by a properly graded sewer of suitable dimensions, and so situated at the outlet that its invert would never be impeded by the highest tides, as per dotted lines on the section drawing No. 4; but Southport being practically on a level plain, it would not be possible to construct such gravitating sewers in the air, as they are shown on that section!!

Drainage of Crossens to cost £5,101.

67. As already stated (60), for want of plans, sections, &c., I am unable to give you anything like a reliable approximate estimate of draining either a part or the whole of Southport on my system; but seeing Crossens, with perhaps a population of 650, standing by itself, and apart, as it were, from Southport proper, and seeing that it is proposed to spend £5101, out of the loan of £20,000 which the Town Council are now applying for, through the Local Government Board, in order to sewer Crossens, I have thought that a comparison of the relative cost of draining Crossens on my system, and draining it on the plan proposed by Mr. Crabtree, might be serviceable.

68. The plan proposed to be adopted by the Town Council is shewn on the drawing No. 5. By that you will see that the same kind of sanitary (?) engineering that has resulted in giving the people of Southport annoyance and anxiety, is to be repeated at Crossens! That is to say, big and badly graded sewers, wholly unsuited to the volumes of sewage available at Crossens, are proposed to be laid. You will see

that the main outfall sewer for Crossens is an egg-shaped sewer 3 feet × 2 feet, and it is to be laid at a gradient of 1 in 1500! (The sizes and gradients of all the tributary sewers are also given upon the plan.) A sewer 3 × 2 feet, laid at a gradient of 1 in 1500, when one-third full, will require 106½ cubic feet per minute of sewage passed into it; and as a population like that at Crossens would barely discharge 2 cubic feet per minute into it, it is easy to understand what will take place in such a *tide-locked sewer!* To my mind, the act of instituting such works of drainage, in the face of the fact that a better system can be substituted for it—one, too, that is in perfect accord with Nature's laws—is *worse* than wasting public money. Better leave the Crossens people as they are, than build a "vast sewage gas-producing apparatus" in their midst, "to pollute the ground they live on, and the air they breathe."

The velocity in the egg-shaped sewer with 106½ cubic feet per minute flowing into it, would be 1·56 feet per second! What could you expect with only 2 cubic feet per minute as a maximum of sewage flowing into it.

69. By placing *three* pneumatic sewage ejectors in the positions indicated on my plan, the sewage accumulating in the village would *quickly* gravitate into them, down the *small, properly graded sewer pipes* (see Section Drawing 4), and, long before it could possibly get into a state of decomposition, it would be ejected out of them into the sea! But, if there is a sensible farmer somewhere in the locality, he will ask the Corporation to allow him to have the sewage!

See drawing No. 5.

70. My estimate for *doing the work, and getting the sewage away without causing a nuisance,*—and NOT for *doing the work, and failing to get the sewage away, and causing a permanent nuisance besides,*—is as follows:—

Gravitating sewers, with flushing tanks and manholes, &c.	£1554	0	0
Ejector stations, sealed sewage, and air mains	1719	10	0
Air compressors, boilers, receiver, buildings, chimney connections, land, &c. (machinery in duplicate)	670	0	0
	£3943	10	0
Contingencies, 10 per cent	394	10	0
	£4338	0	0
If compressors are established where boiler power already exists ..... deduct	440	0	0
	£3898	0	0
Annual cost of working, exclusive of attendance, £25 per annum, capitalized at 20 years, costs	500	0	0
	£4398	0	0

Shone's Pneumatic system, proposed for Crossens, available for dealing with the sewage of 5,000 people, by connecting fresh inexpensive gravitating pipe-sewers, to the present scheme, and constructing additional ejector stations, in the same way exactly as water and gas supplies are extended into growing districts.

71. The boiler power and air compressors provided for, would be powerful enough to deal with the sewage of 5000 people, and all that would be required to extend the system, as the population grows, would be to take a little air pipe to the spot where the sewage of the new population could be laid hold of, fix a pneumatic ejector there, and eject it into the iron sewage main, &c.

72. I have omitted attendance in the above estimate, for I do not know whether it would be practicable to fix the compressors where power already exists, and so dispense with separate attendance, which latter would, in a small and isolated scheme of this nature, be large in proportion to what it would be if, for instance, the system were applied to other portions, or the whole of Southport. In any case, although Mr. Crabtree does not shew it, attendance would be necessary in connection with his scheme also.

73. I believe that if I had had the opportunity, I could have pointed out a way to Mr. Crabtree by which many of the sewers which are proposed to be laid in Southport anew, and in substitution of existing old sewers, could be dispensed with, and my system put down in their place; and the work done in such a manner as to be a much greater improvement upon the existing sewerage system, *i.e.*, in those parts where new works are prospected, than would be the case otherwise. Moreover, I believe too, that by a judicious manipulation of the pneumatic and hydraulic ejectors, *the present flushing and ventilating arrangements* could be, sanitarily speaking, economically augmented and altered for the better.

Important statement by Mr. Crabtree.

74. Mr. Crabtree, in his Report to the Chairman and members of the Health and Highways Committee, dated 8th February, 1883, states—"We have no ream water available for flushing with, where it is most needed, at the upper ends of our sewers." In another part of the same Report he states—"These sub-soil drains may be multiplied "in many of the sewers; to reduce the level of the water in the ground "is worth considering on the score of health, and so long as it "increases the quantity of ordinary sewage, and does not immediately "affect the quantity flowing during rainfall, it may safely be used." This makes me think that the ground in Southport at a certain level is charged with what is called ream water; but that this ream water is unavailable for flushing, at the heads of the sewers, where, as Mr. Crabtree rightly observes, "it is most needed." By the employment of pneumatic ejectors, *this ream water, as well as the bath waters, could*

be utilized at the heads of the sewers, where flushing is "most needed." At present, *potable water*, pumped from a great distance, is used largely for flushing purposes! The expenses incident to the ineffective system of flushing would go a long way towards establishing as effective a system of flushing as it is possible to establish, having regard to the conditions that obtain at Southport.

Present system of flushing, costly but ineffective.

75. I have traversed all the important points that I can think of in connection with the subject which you have taken in hand; and I do not know that I can do better than conclude my report—which I sincerely hope will be serviceable—with another quotation from Mr. John Phillips, C.E., taken from his pamphlet on the "Drainage and Sewerage of Towns" (published by Messrs. Spon and Co., London). It is as follows:—"Nothing is more harassing to the inhabitants of "towns than to be continually annoyed by defective drainage and "sewerage, and to be endeavouring periodically to abate fevers and "epidemics occasioned thereby. It has been said that *it is not now "possible to revert to the separate system in towns, because, the surface "being already drained and the sewage from the houses being already "carried off by the single or combined system, the alterations would be "attended with enormous difficulty and cost.* Nothing, therefore, remains "but to continue to battle with the present system. *When, however, "it is determined to remedy it, no system of works would lead to that end "so surely and so satisfactorily as that of the double or separate system "of drains, which could easily be arranged and constructed, and the "sewage utilised and purified by the process of irrigation and land "filtration*, as I have pointed out. And with reference to the present "drains and sewers in towns, they could be made to conform to this "system without much difficulty and expense. *It should be borne in "mind that, as regards the sewerage and the disposal of the sewage, a "great evil is to be remedied; that palliatives act only locally and tem-"porarily, and are wasteful of means;* and that it is *far better and in "the end much cheaper to work in accordance with sound principles that "will lead to permanency and success.* Clear and defined plans with "these objects in view could easily be laid down, and the works "carried out as circumstances and funds permit."

Mr. Phillips' views well worthy of the consideration of the Town Council of Southport, at the present time.

I have the honor to remain, GENTLEMEN,

Your obedient Servant,

ISAAC SHONE, C.E. & M.E., F.G.S.

T. BRAKELL, PRINTER, LIVERPOOL.

SCOTTISH EQUITABLE CHAMBERS,
19, CASTLE STREET,
LIVERPOOL, 16*th April*, 1883.

DEAR SIR,

As Chairman of the Committee constituted for removing the nuisance of sewer-gas from the houses and streets of Southport, I have to convey to you my own and my colleagues' warmest thanks for the very exhaustive and valuable report which we have received from you.

We are of the opinion that the issues raised by you are of immense importance, alike to Southport and the United Kingdom at large.

Your scientific exposé of the defects in the water-carriage system, which are made so apparent by the table and sections accompanying your report, is the more to be appreciated, because, as it appears to me, unlike all your predecessors, (Mr. Rawlinson, C.B., C.E., not excepted,) you have not only given us to understand that sewage in sewers must have velocities of from 2½ to 3 feet per second given to it, in order to keep the pipes carrying it to the outfall free from deposit and free from dangerous emanations of sewage-gas, but you have also devised a scientific and practical way of securing those velocities under all sorts of adverse conditions.

I have confidence in making this statement to you, for my Committee had not only been at great pains, as you are aware, to understand the principles on which your system of drainage is based, but it has also, unawares to you, made inquiries concerning the working of the system at Eastbourne and Warrington, the replies to which are most satisfactory, as the copies of letters in our possession will testify.

In one respect your report is a disappointment to the Committee. You do not shew how you could deal with some section of the town of Southport itself.

The people at Crossens and Churchtown have made no complaints about smells or nuisance, although, doubtless, they soon will do if the gravitation scheme proposed by the Town Council is carried out there.

The memorial presented to the Town Council, complaining of the present system of drainage, was largely signed, for instance, by ratepayers resident on the line of the Albert Road sewer.

Could you not, therefore, give us a sketch plan and approximate estimate for the application of your system to the Albert Road district, with such portions of the streets immediately abutting thereon, as would enable the Committee to put a practical scheme, applicable thereto, before the Local Government Board Inspector, Major Tulloch, C.E. ?

As it is the intention of the Committee, in view of the great importance of the subject of your report, to print it *in extenso*, and to distribute it amongst such of

the members of the Town Council as may be expedient, I hope you will oblige us at your early convenience with proposals for dealing with the sewage of the Albert Road district.

Believe me, dear Sir,

Yours very truly,

ISAAC SHONE, ESQ., C.E.,
Wrexham.

JOHN J. BANNING,
of 28, *Westcliffe Road, Southport.*

[*Copy of one of the letters referred to in above letter.*]

14, SEASIDE ROAD, EASTBOURNE,
March 28th, 1883.

JOHN B. FELL, ESQ.,
68, Leyland Road, Southport.

DEAR SIR,—Your letter to the Duke of Devonshire, respecting the application of the Shone system to Eastbourne, has been forwarded to me to reply to.

The Shone system was adopted here about two years since, to supplement the existing sewers, and I am glad to be able to inform you that the working of the system has produced very satisfactory results.

The gravitating sewers were constructed for a population of about 15,000 people, but Eastbourne having increased so rapidly, it became a serious question as to how additional facilities for getting rid of the sewage should be provided, and it being considered of the utmost importance to provide for the emptying of the sewers under every condition of tide, the matter was somewhat difficult of treatment. A very careful enquiry was therefore instituted into the working of the Shone system, which was ultimately adopted, and by means of the ejectors, worked by compressed air, *adapting themselves to the intermittent flow of sewage, impounding is prevented, decomposition does not set in, and, therefore, bad smells are not generated.*

The system at first was confined to the outfall works, and, having been found to work satisfactorily there, it has been extended to a second station, fully two miles distant from the air-compressing station. A 4in. air pipe is laid down to connect the air-compressing station with the second ejector station, and the same satisfactory results have followed.

I am of opinion that wherever good gradients cannot be obtained, the system can be applied with great advantage; and, should you think of adopting it at Southport, I should be happy to make arrangements for you to see the works here in operation.

I am, Sir, yours faithfully,

GEO. A. WALLIS.

P.S.—The system, I believe, is shortly to be extended to a third station.

PENTREFELIN HOUSE,
WREXHAM, *April 21st*, 1883.

JOHN J. BANNING, ESQ., 28, Westcliffe Road, Southport.

DEAR SIR,

Your letter, acknowledging the receipt of the Report, which I had the honor of addressing to your Committee on the 17th inst., came duly to hand; and, whilst regretting that the Report was disappointing to you in one respect, I could not but feel pleased that you were sufficiently impressed with it, as a whole, to decide to have it printed, for circulation amongst a few Ratepayers outside the limits of your Committee. I may be wrong, but I cannot help thinking that, if the members of the Town Council of Southport thoroughly comprehended the points which I endeavoured to explain in the Report to your Committee, they would rise as one man to oppose proposals having for their object sewer extensions on the lines of the present system of drainage.

Estimated cost of Southport Drainage, £200,000.

Rumour hath it, that when the present proposed loan of £20,000 has been expended, the Southport drainage will have cost altogether about £200,000. The rumoured rough estimate being made up as follows:—

1. Money spent on the drains and sewers before Mr. Mansergh, C.E., touched them	about	£40,000	0	0
2. Money spent on Mr. Mansergh's Plans	,,	140,000	0	0
3. Money now required	,,	20,000	0	0
		£200,000	0	0

Southport Drainage Works, deteriorated property 30 per cent.

Whether this estimate is correct or not, I am unable to say; but, apart altogether from the unsanitary aspect of the expenditure, the sad thing about it is, that the cost, whatever it has been, so far from enhancing the value of the property in Southport, as all drainage works ought to do—the money spent has actually had the practical effect, according to the published opinion of your Committee, of deteriorating the value of property in Southport, to the extent of something like thirty per cent.!

Drought.

If it has had this effect already, I am afraid that a degree of deterioration greater than that roughly estimated by your Committee, would follow a year of drought, for instance.

Sir J. B. Lawes, Bart., record of rainfall for 30 years.

I received the other day, from Sir J. B. Lawes, Baronet, an abstract of 30 years carefully taken records of the rain which fell at Rothamstead,—and it is as follows :—

	Mean of each 6 years.
1853 to 1858.....	25½ inches.
1859 „ 1864.....	26½ „
1865 „ 1870.....	27⅓ „
1871 „ 1876.....	29¾ „
1877 „ 1882.....	33¾ „
Mean of 30 years...	28½ inches.

Increase of rainfall beneficial so far as the Southport sewers are concerned.

You will see that there has been a steady increase in the rainfall, in the past 30 years, and especially in the period during which the big sewers of Southport have been constructed and in operation, *i.e.*, in the 6 years ended 1882. The rates of mortality would have been higher than they are, were it not for the heavy rainfall to which this country has been subjected since 1876; and this is a view of the question of drainage, as it affects Southport in particular, which is important, and I avail myself of this opportunity of bringing it to your notice, as, should the rainfall be less in the future than it has been in the past, there will, of course, be less water to charge the surface and subsoil, and ergo, the subsoil drains and sewers of Southport; for just as the rainfall diminishes, so will the nuisance and danger arising from smells increase.

The evidence of Sir Joseph Bazalgette and Mr. Brierley, C.E., against the present Southport Drainage System.

Since I wrote my first Report to you, I have carefully perused the evidence which Sir Joseph Bazalgette, and Mr. Brierley, C.E., (of Blackburn) gave before a Committee in the House of Commons, against the drainage system of Southport, before the works were commenced. The reperusal of those gentlemen's evidence ought, I should say, to influence the Town Council of Southport, *at the present time*, if it failed to have the desired effect in 1875! Moreover their evidence will corroborate the views enunciated in my first Report to you, and under the circumstances, doubtless, it may aid your cause if I now reproduce those portions of their evidence which I consider the most important. I have pleasure in doing so, under the heading "Appendix." See pages 10 to 12 inclusive.

Scheme for Albert Road District, on the Shone System of Drainage, shewn on Drawing No. 6.

For the reasons set forth in paragraph 60 of my first Report, it is really impossible for me, now at all events, to suggest the *best* plan of dealing with the sewage of the "Albert Road district" *on my system;* but, as you express a strong wish that I should do the best I can, in the absence of correct plans and sections of the existing drains and sewers in that district, I beg to submit the scheme shewn on drawing No. 6—as merely illustrative, however, *of what can be done*, than as a scheme which I should recommend to be carried out.

The drawing, with the reference which is attached to it, will explain itself. You will see that I have placed four pneumatic ejector stations within the district shown. The sewage immediately within the reach of each pneumatic ejector would flow quickly thereto, under the power of the law of gravitation—because the conditions necessary for it to do so would be created by the construction of small new sewers, suitable for the purpose. The existing drains, or sewers, to be retained for the passage of rain-water into the big main sewer, under Albert Road. The sewage aggregating into each ejector might be ejected into the big main sewer at the south-east corner of Hesketh Park, where it would assist to flush that sewer from that point northwards. The existing sewers would do admirably for rain and subsoil water drains.

Llandudno drained on the "Separate" System.

At Llandudno, which was sewered by Mr. Baldwin Latham, C.E., he advised the adoption of the separate system, and his plans were carried out; the old drains being retained for surface and subsoil water, and the new ones were constructed for sewage pure and simple.

Dr. Richardson strongly in favour of the Separate System of Drainage.

I entirely agree with the advice tendered by Dr. Richardson, in his excellent paper on "Health in a Health Resort," which is inserted in *Longman's Magazine* for March, 1883, *i.e.*, he there states: "Separate "the storm water from the water used for domestic purposes, and from "the sewage of the town. *Do this at all costs*, so that absolute self-"cleansing is the persistent method in force."

If Albert Road District were dealt with first, the other parts of Southport could be tackled afterwards, should the Albert Road District, sewered on the Shone System, work satisfactorily.

This proposal, or something like it, if carried out, would enable the Corporation to see whether the "separate system" would not be better than the combined system.

The nuisances arising from the present tributary and main sewers, can only be effectually suppressed by discontinuing their use as sewage carriers, because I apprehend that the gas generated in the big main sewers can pass freely out of them into the tributary sewers, and vice versâ; and, in all probability, the gas generated in both has free access

to the house drains also! In this way, sewer-gas formed within the boundary of private property is permitted to escape into the public sewers, and vice versâ!

No plan of Ventilation will remove the cause of sewage gas nuisance in Southport.

To attempt to tinker with the present main and tributary sewers by ventilating them, no matter how, would be attended with failure; whilst the cost of the work would go a long way towards the cost of instituting a plan of drainage that would result in the permanent suppression of the cause of the sewage-gas nuisances of which you complain.

The reclaimed building land shewn on Drawing No. 6.

It would be a pity, after spending so much money on reclaiming the splendid building land shown on drawing No. 6, to construct sewers within it, and afterwards to let them have direct communication with the present unsanitary sewers. The act of doing so would be precisely the same in its results as that which would follow the laying of gas-pipes there; that is to say, the sewage-gas would be laid on to the "reclaimed building land" from the main and tributary as well as from the house drains; and the gas for lighting would be laid on there from the gas-main connected with the gasometers of the Gas Works; the only difference between the *modus operandi* adopted for the distribution of the two gases being, that, in the case of the coal-gas, its passage would be impeded and controlled by taps, whereas in the case of the sewage-gas it would have free and uninterrupted access to the premises!

Sewage gas laid on to premises, &c.

Drawing No. 6 embraces 210 acres.

The drawing No. 6 embraces a district containing about 210 acres, as you will see, which is already more or less built upon. If the whole were covered over with buildings—much as blocks A. B. and C. are covered over—the land would ultimately accommodate from 4,000 to 5,000 people.

Estimate for dealing with the Albert Road District.

My estimate for dealing with the sewage of the larger population of 5,000, on the pneumatic plan, reckoning the sewage discharges at 20 gallons per head per day, amounts *(a.)* to £6,500.

The estimate includes the providing and laying of new gravitating sewers, all iron sewage-mains, iron air-pipes, pneumatic ejectors and their chambers; but *not* the cost of the air-receivers, sluice and stop-valves, air and steam-pipe connections, compressors and boilers, engine and boiler house, chimney, and site of air-compressing station; neither does it include annual attendance and fuel cost, for the reason that the district to which the estimate applies, forms only about the one-tenth part of Southport.

But, reckoning a population of 50,000 in Southport, and the sewage discharges equal, on the average, to 20 gallons per head per day, and dealing with the whole on my system, the cost of the compressing plant, in duplicate, including buildings and site, would be about £6,000. If we add to this the attendance and fuel cost, capitalized, viz.: £8,480, we have a total of £14,480; dividing this again by 10, we get at the first cost of the site, buildings, &c., and machinery, and the capitalized cost of the fuel, attendance, &c., chargeable to the Albert Road section of Southport, which is equal to £14,480 ÷ 10 = £1,448; adding this latter sum again to the £6,500, the first cost of the works in the Albert Road district, we have a total of £7,948, which is equal to about £1 12/ per head of the population provided for.

The Shone Drainage System applied to the Albert Road District would cost about £1 12s. 0d. per head.

In judging of the cost per head, and comparing it with the cost already incurred, I must again remind you of the great difference there is between works which failed, and drainage works which do not fail to accomplish the objects for which they are instituted. Direct monetary comparisons, under such circumstances, are misleading in the extreme.

Putting Sanitary and Unsanitary Drainage Works on a par, estimates as to their relative costs misleading as to their relative values.

I remain, dear Sir,

Yours faithfully,

ISAAC SHONE.

J. J. BANNING, ESQ., Southport.

DEAR SIR,—Dr. Wright, of 17, Alexandra Road, Southport, who is, as you are aware, one of your Committee, having requested me to give a drawing of the pneumatic sewage ejector in this report, which would enable my readers to understand what sort of apparatus it is, I have pleasure in complying with his request. Fig. 1 is a pneumatic sewage ejector of the type now used at Warrington, the successful working of which (as I have been informed by Mr. Thos. Longdin, C.E., the Borough Engineer of Warrington) Dr. Vernon, the Medical Officer of Health, and Mr. Crabtree, C.E., the Borough Engineer of Southport, witnessed this week.

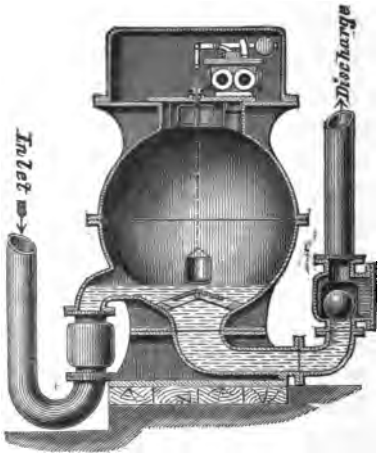


FIG. 1.

Figs. 2 and 3 will help you to understand its action. The sewage passes from the stoneware gravitating sewers, into the iron ejector, through the iron inlet pipe; and it passes out of the ejector through the iron outlet pipe. On both pipes there is a ball valve—the one on the inlet to permit the sewage to enter into, and at the same time to prevent it from returning out of, the ejector,—and the ball valve on the outlet, whilst it permits the sewage to pass out of the ejector into the iron sewage main, which conveys it to the outfall, it will not permit it to return to the ejector. Fig. 2 shews the ejector as it would appear (if it were made of glass, for instance,) at the moment the full charge of sewage had been ejected out of it, via the outlet pipe, into the iron sewage main. The compressed air would drive the sewage out down to the level

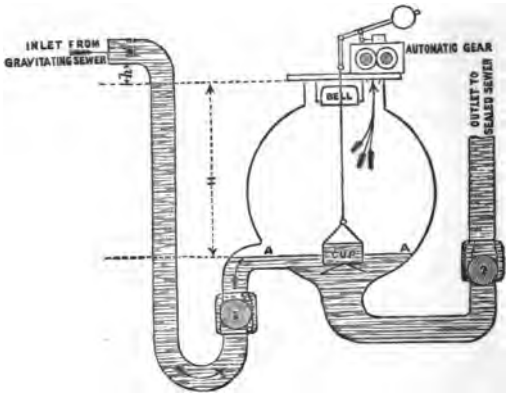


FIG. 2.

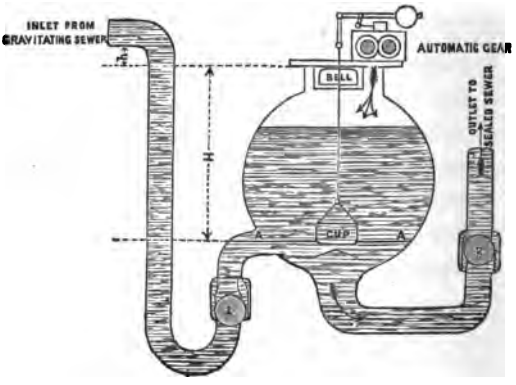


FIG. 3.

"A A," but at that level the "CUP" would pull down the rod connected with the "AUTOMATIC GEAR," and the effect of that would be (1), to stop *instantly* the inrush of any more compressed air, and (2) to permit the compressed air, which had ejected the sewage down to the level "A A," to escape. Fig. 2 shews by arrows that the compressed air is escaping. When all the compressed air has escaped, atmospheric pressure obtains within and without the ejector, and the very moment the sewage column in the inlet pipe exerts a pressure per square inch at the level "A A," within the ejector, greater than that which would be due to the escaped and escaping compressed air, that very moment the sewage in the inlet pipe would rush into the ejector at a velocity due to the heads of water "H + h." The sewage ejected into the outlet pipe would at that time be quiescent, resting on the ball of the outlet pipe of the ejector.

When the ejector got filled again, the "BELL," situate at the top of the ejector, would reverse the pulling action of the "CUP," when the charge of sewage in the ejector had been ejected down to the level "A A," and the effect of that would be, to admit compressed air into the ejector. The moment the compressed air pounced on the surface of the sewage in the ejector, simultaneously the ball valves would act—the inlet closing, and the outlet one opening. The arrows in this fig. 3 are intended to represent the compressed air rushing into the ejector, and displacing its sewage contents, by forcing it out through the outlet pipe to any required outfall.

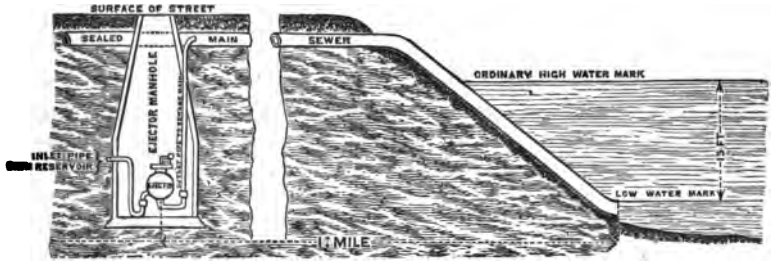


FIG. 4.

Fig 4 is intended to shew how, by the employment of these pneumatic sewage ejectors, sewage can be forced into a sealed iron sewage main, common to any required number of ejectors, as per drawing No. 4, for example; and, regardless of the fact that the sewage main is laid under a practically level surface, and that the outlet is below "low water mark," and made to flow into the sea, regardless of the state of the tide, as is the case at Eastbourne, where the Shone system has been in operation for some time, thanks to the enterprise of his Grace the Duke of Devonshire and the Eastbourne Local Board.

I hope the illustrations, and my explanations of them, will be thoroughly understood by the Committee.

I am, dear Sir, yours faithfully,

ISAAC SHONE.

Appendix, referred to on page 4 in Report.

Extracts from Evidence given by Sir J. W. Bazalgette, C.E., and Mr. Joseph Brierly, C.E., before Committee of the House of Commons on Southport Improvement Bill (1875), 20th April, 1875.

SIR JOSEPH W. BAZALGETTE, ENGINEER TO THE METROPOLITAN BOARD OF WORKS, SWORN.

Examined by Mr. Littler.

Q. 242. What do you say will be the condition of matters within Mr. Hesketh's property during the stoppage for three and a half hours each tide?——*A.* I have no doubt that a deposit would necessarily take place in that sewer throughout the whole length that traverses Mr. Hesketh's property.

Q. 243. I see a word in your proof which seems to me to express very much the condition of things. You call it here an elongated cesspool?——*A.* Yes.

Q. 244. That is the condition of things so long as it lasts?——*A.* Yes, it must be necessarily so; that is my opinion.

Q. 247. Have you heard this morning the description of those gates for flushing purposes?——*A.* My experience is that these gates will do more harm than good. We had them formerly in London, and they have been given up—abandoned. The operation of these gates is that the gate is closed across the stream; the stream is admitted to be so sluggish that its regular flow will not carry the deposit out of the sewer; the gate closed across that whilst the sewage is accumulating behind it, necessarily increases the amount of deposit. It, in point of fact, makes a stagnant pool for a time. Then when the gate is opened, a flushing takes place for a time, and carries the deposit a short distance further on, throwing up a bank in front of it again; and I think that constant disturbance of the deposit rather tends to evolve gases from it than to do good, and does not clear the deposit out of the sewer.

Q. 248. Have you found, on visiting sewers where the flushing system has been carried on, that the stuff is in ridges along the bottom of the sewer?——*A.* It is. I have traversed sewers which have been so treated, in London, and have found that for a short distance you go over a piece of sewer tolerably flushed clean—then you come into a deep body of sewage, and climb over that again. It is like a bar formed at the mouth of a river.

Q. 249. I will come to the level in a moment; but what do you say to that condition of things existing under an Estate like Mr. Hesketh's, which, you may take it from me, is coming into the market as a building estate for villas?——*A. I think it is very undesirable.*

Q. 250. Do you think it would be a serious injury to his property, at all events in people's eyes?——*A.* I do; it has been laid down by the most experienced hydraulic engineers, that a velocity, when a sewer is running half-full, of something like a mile and a half an hour, is necessary to keep the sewers free from deposit, and my experience agrees with that view. I can quote Mr. Hawksley, Mr. Wickstead, Mr. Rawlinson, on his theory of rivers, and a variety of experimenters, on the subject, and they all very much agree on that point.

Q. 251. That which is the general theory of experienced engineers, is what you have found in your general practice in carrying out these sewers?——*A.* It is.

Q. 252. You will find it is absolutely necessary, to secure what you would call proper purification of the sewers?——*A.* Yes; to remove ordinary deposit from the sewers, *you* will only get half that velocity, therefore, unless we are all wrong on the subject up to the present time, there must be deposit taking place in the sewers.

Q. 253. So far as you know, has recent experience at all tended to confirm instead of weakening the view which has been proposed?——*A.* Yes, there is no ground for doubting it.

Q. 254. Unless the circumstances were such as to make it impracticable to do anything else, would you suggest such a thing as a fall of one in five thousand?——*A.* I would not. The best proof I can give of that is, that none of the outfall sewers in London have a less fall than two feet in a mile.

Q. 255. That is one in how many feet?——*A.* That is about double the fall of this, but then the velocity of the flow is very much better than would be obtained in these if they doubled the fall, because the quantity of water flowing through these sewers is much larger. We must bear in mind that it depends upon the size of the stream, and the flow. For instance, a fall of 4 inches in a mile, in the river Thames would give the same velocity as 15 feet in a mile would in a small stream. Therefore, if sewers 10 feet in diameter, running half full, require a fall of 2 feet in a mile to give them a sufficient velocity, a sewer carrying this amount of sewage, would require very much more fall.

Q. 256. Then this is an *à fortiori* case?——*A.* In my judgment this sewer should have a fall of at least 5 feet in a mile.

Q. 257. That is a judgment which is borne out by your experience wherever it has been?——*A.* Yes; that is what I should have recommended in this case, certainly.

Q. 258. Now, although ventilation, of course, is a very great protection against an evil of this kind; with any ordinary amount of ventilation that can be put in, in your judgment, would this still be a defective and objectionable scheme?——*A.* Yes, I think so, the ventilation, of course, enables the sewer gas to escape into the open air, instead of going into the houses.

Q. 259. But still, stopping back the outfall, and letting this stuff deposit at an almost flat gradient, simply brings those gases out on a level with the street, and the people must inhale them more or less?——*A.* This is certainly not a scheme I should have recommended.

MR. JOSEPH BRIERLEY, C.E., M. INST. C.E., BOROUGH ENGINEER OF BIRMINGHAM, SWORN.

Examined by Mr. Onslow.

Q. 218. What is your opinion now, speaking generally of these works as proposed, so far as they will affect Mr. Hesketh's estate?——*A.* I was desired to report on behalf of the Rev. Mr. Hesketh, as to how far this proposed work might affect prejudicially or otherwise, his estate, and having carefully reviewed the whole matter, I came to the conclusion that it must inevitably be an injury. They have a sewer of two miles or a little more in length, in which the sewage is impounded during intervals of high water, averaging, as has been given in evidence, probably, about four and a half hours a day. The very slight grade of the invert, added to the impoundage, makes the sewer, to speak of it fairly, an elongated cesspool, or an elongated reservoir of sewage. During the time of impoundage, the solid matter in suspension naturally will settle on to the invert, and will require some special means for removal.

287. *Q.* Can you tell me what you think is the main objection to the proposed sewer so far as Mr. Hesketh's estate is concerned. To take it by degrees, as to the locking of the sewer?——*A.* The first element in a sewage scheme is that it should remove effectually from the town, to some point, the whole of the accumulated sewage of the district. This scheme entirely fails to do that. If you take the diagrams and plans, which are very fairly drawn, it will show that during the time of tide-locking, we have an impoundage which throws the sewage back, under a very considerable part of the residential property of the town. That itself is a very fatal objection to it.

Q. 288. That is to say, the sewer being locked by the tide during, as we have heard, three and a half to four and a half hours a day, the heavy matter in the sewage will deposit in the sewer?——*A.* And can only be removed by flushing.

Q. 289. What is the effect of flushing?——*A.* I think the effect of flushing as described, which means agitation along the line of the sewer of the accumulated solid deposit, and excretal matter from the water-closets, and that sort of filth, will be decidedly a nuisance, and also objectionable. There is one point which will show that at once. The cesspool system prevails now, as a rule, and the water-closets are run into brickwork cesspools; but it is proposed for the sewage scheme when completed, that the cesspool system shall be abandoned, and it is very probable that the water-closets will be connected with the main sewer.

Q. 290. What is the effect of this sewer being locked upon the gases in the sewer. Where would the gas go?——*A.* A fresh number of ventilators along the line of the sewer, will provide for the ventilation. But there is an objection which arises from the fact of the impoundage in connection with the branches. Because the branch sewers from the dwellings will naturally, during the time of impoundage be submerged,—the apertures will be submerged; and the sewage from the dwellings during that period, not having any other outlet, will naturally have a tendency to force back the gas to the dwellings.

Q. 291. That is to say, as the feeding drains into the main sewers are checked?——*A.* They will be submerged partially.

Q. 292. The gas in that sewer will be driven back into the house?——*A.* There is a tendency in that direction very much.

Q. 293. Do you know how it is proposed to work these flushing gates?——*A.* I do.

Q. 294. What number of gates are there on the plan?——*A.* Thirty-seven.

Q. 295. How long do you think it will take a man to work each gate?——*A.* The working of the gates will be a matter of more or less men, but I think three men probably might manage them in the place which is proposed. There would always be this to contend with. The period of the height of the tide varying each day; there would be a good deal of night work necessarily, from the evidence I have heard, but I think three men or four men might carry out the arrangement which is suggested, over a distance of two and a quarter miles.

Q. 306. What is the effect of sewage being stored on the sewer walls?——*A.* The back water in the sewer, in the manner described by Sir Joseph Bazalgette, entirely throws the sewage matter up to an artificial elevation in the sewer; during that time, the sewage matter is settling in and upon, the walls of the sewer and invert. When the flushing is taking place, those walls are covered with mucous and fœcal matter, which adheres to the sides of the sewers. One can imagine the effect of house drains and connections being connected with a sewer of that kind. With a large chamber of brickwork continually affected by this mucous and fœcal matter.

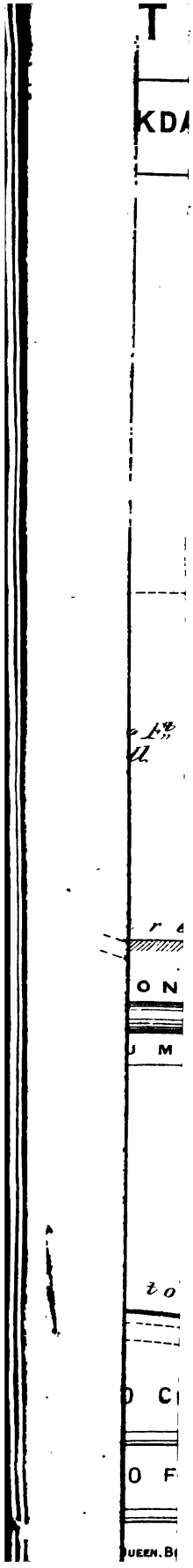
Q. 307. Does that putrify?——*A.* It is the most dangerous element we have to deal with.

Q. 308. Is that a serious feature in a question of a tide locked sewer?——*A.* It is.

Q. 309. In your opinion, will the provision Mr. Mansergh and others stated as to flushing provide for that?——*A.* I am perfectly confident that no flushing arrangement, such as has been described, can possibly cleanse that sewer.

Q. 315. You think the very fact of the sewer passing through this estate in the form in which it is proposed to pass, will seriously injure the estate as a building estate?——*A.* I believe so. And I don't believe I can find a better expression for it than the expression in one of Mr. Mansergh's reports, when he talks of the very fact of the suspicion of a nuisance being prejudicial, and it is so.

T. BRAKELL, PRINTER, 58, DALE STREET, LIVERPOOL.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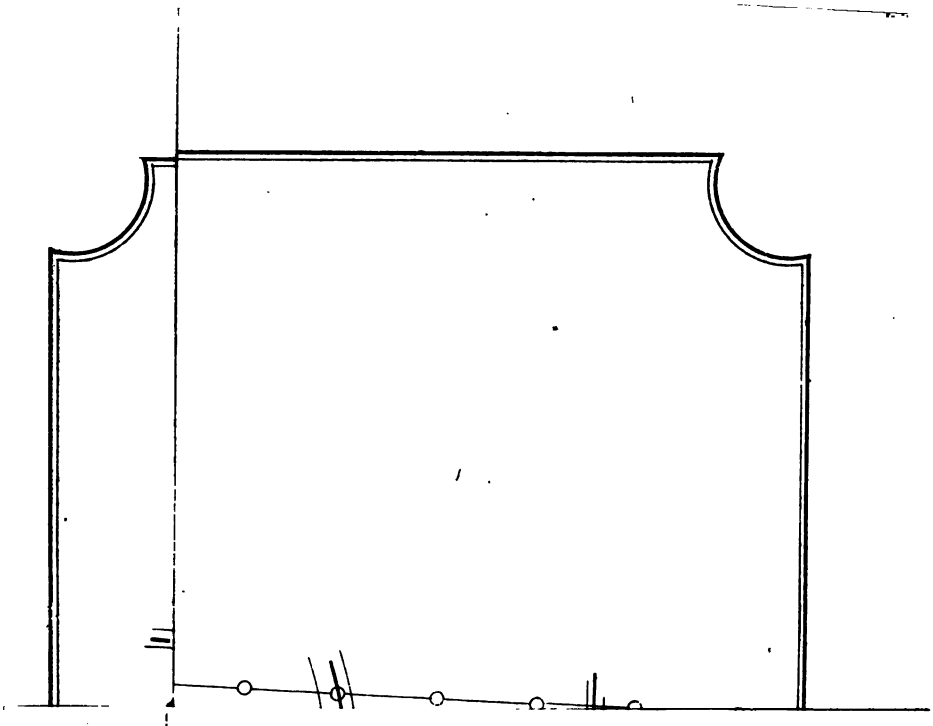

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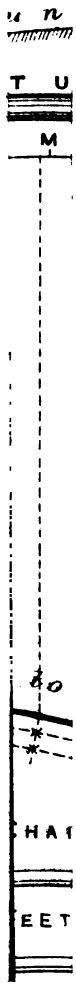
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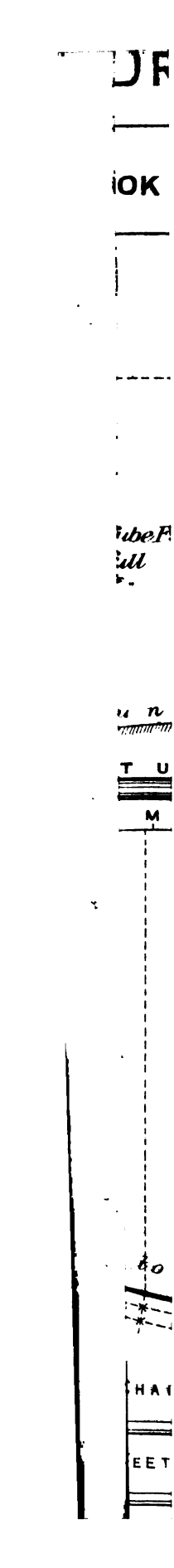
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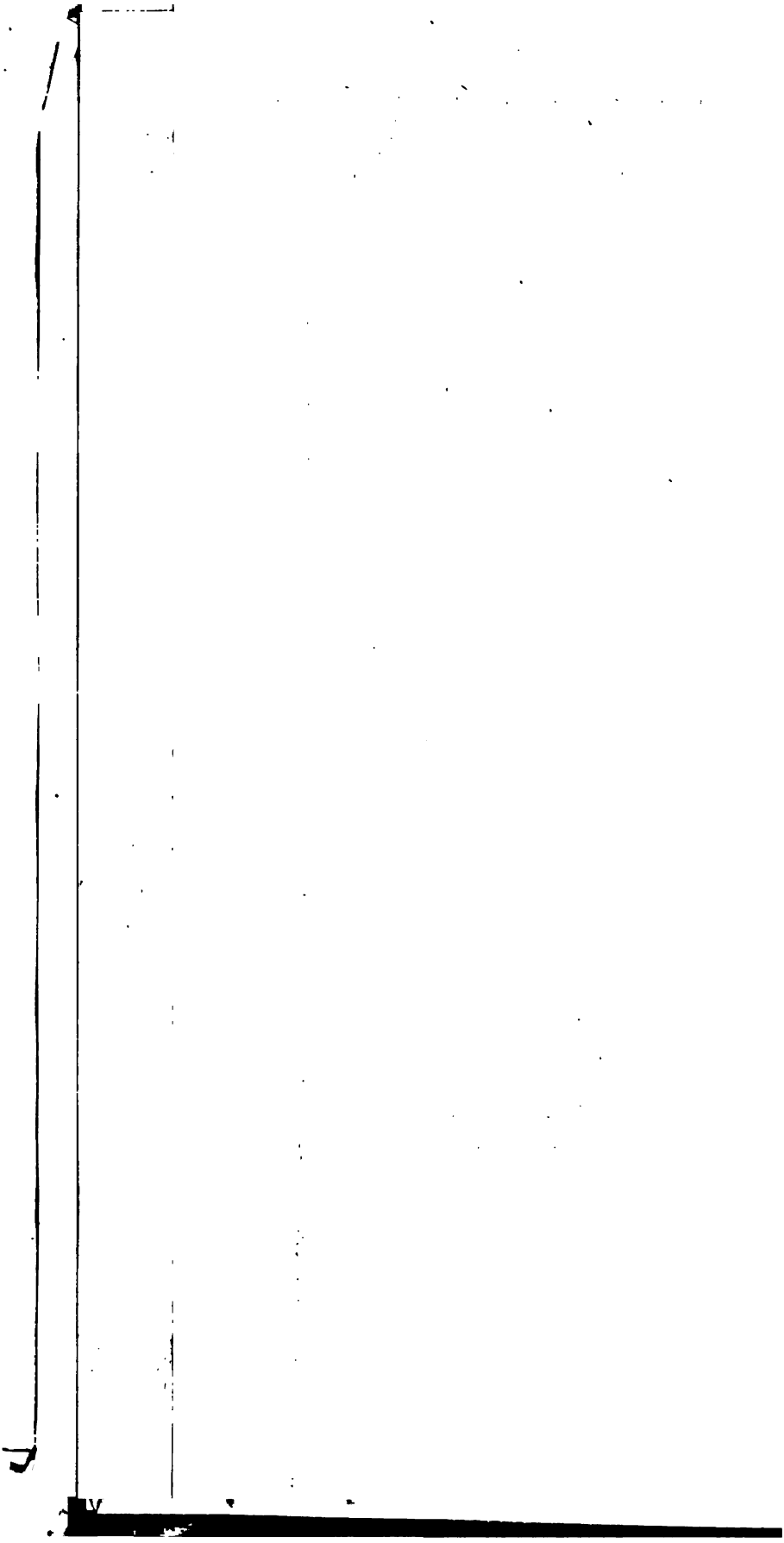

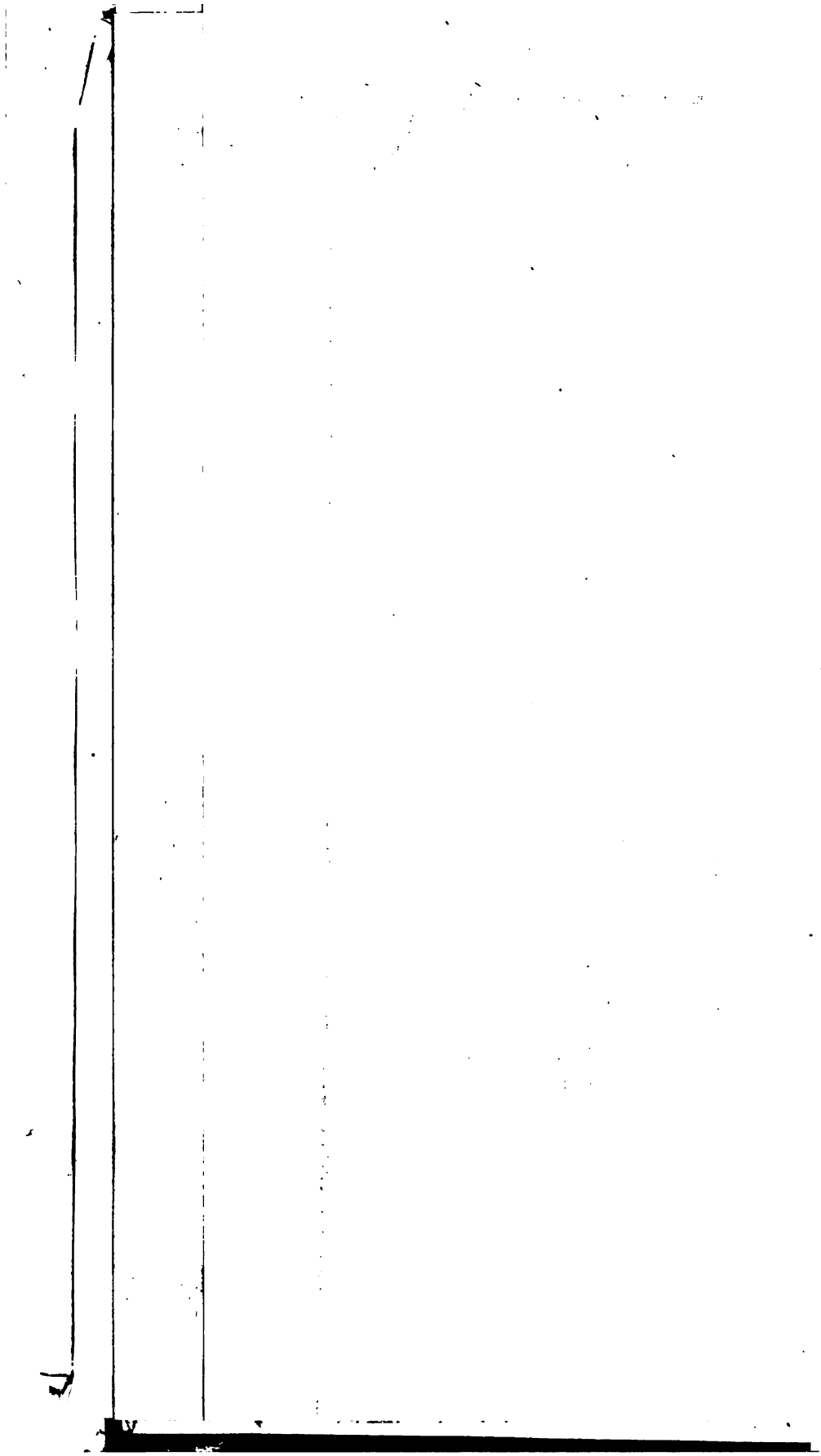

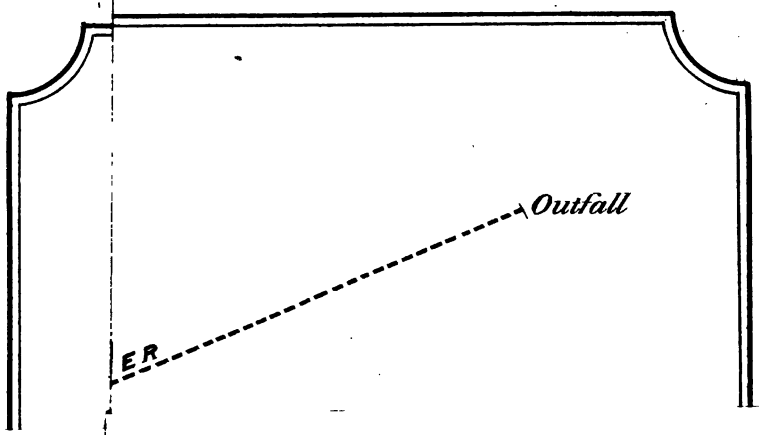
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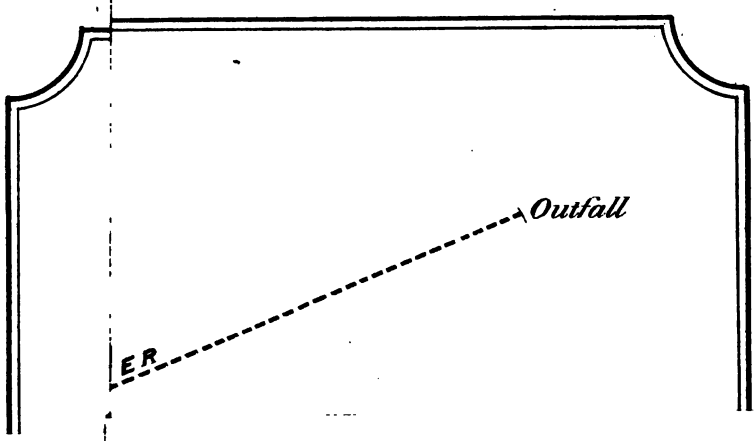
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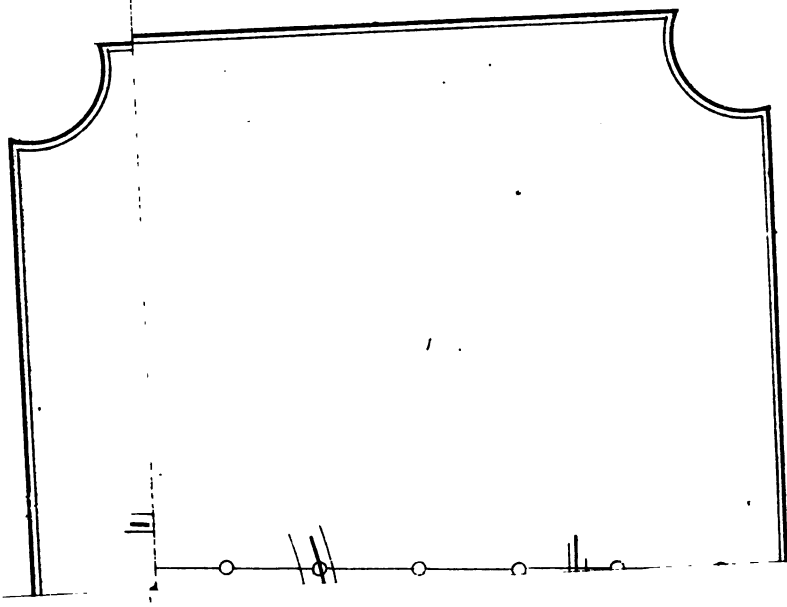

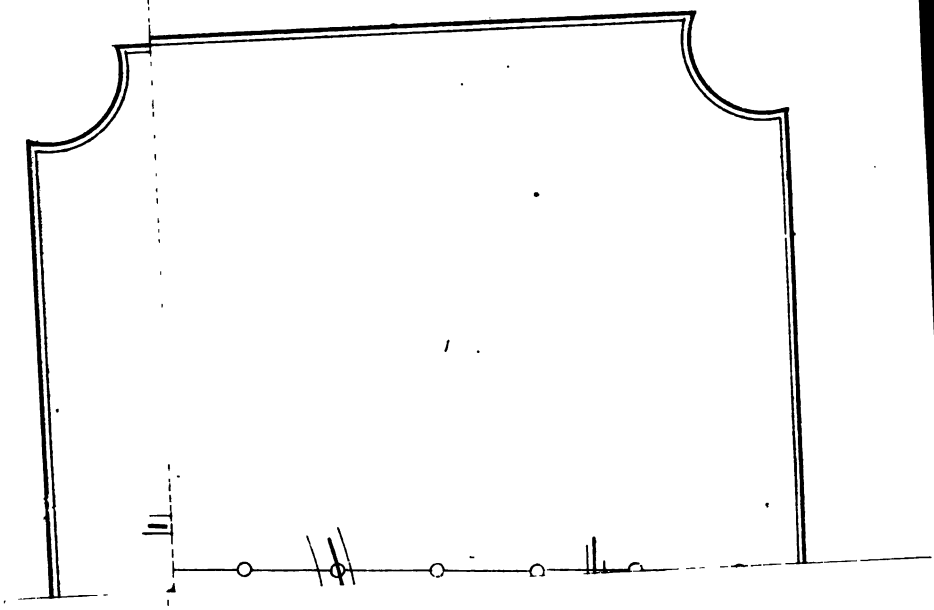

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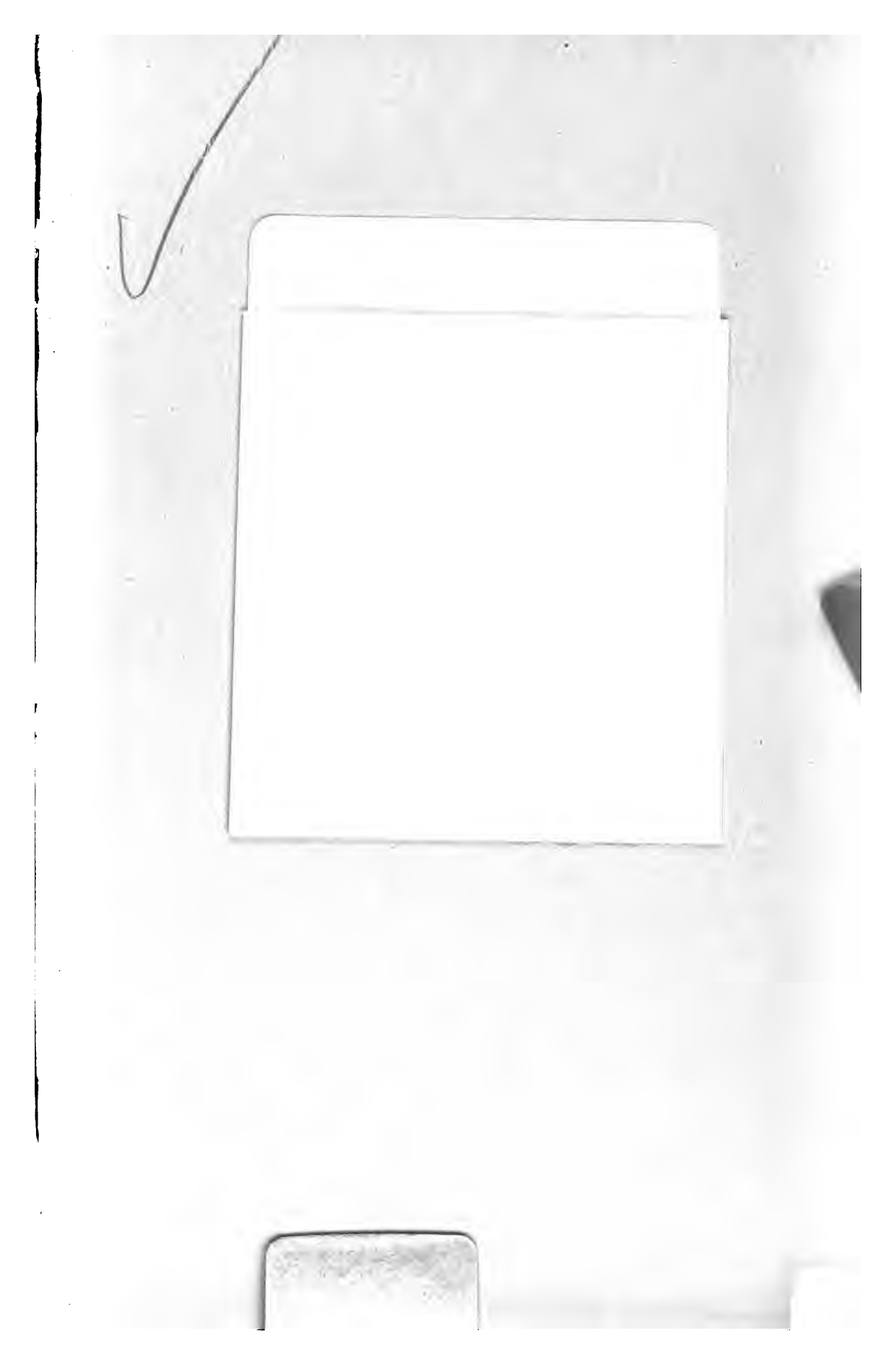

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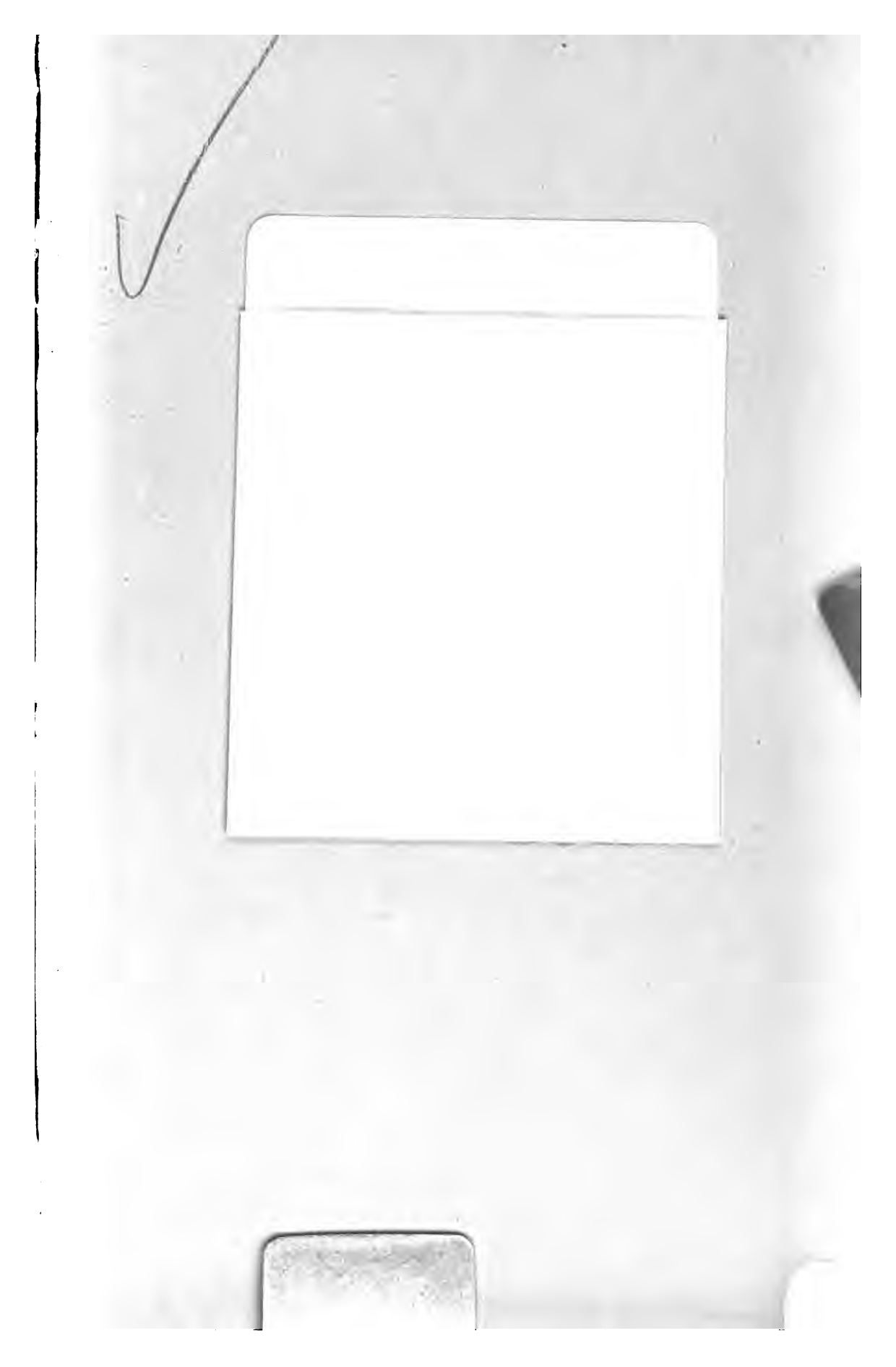
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